

**Final Site Investigation Report
Remedial Action Plan
Boise Towne Square Mall
Boise, Idaho**

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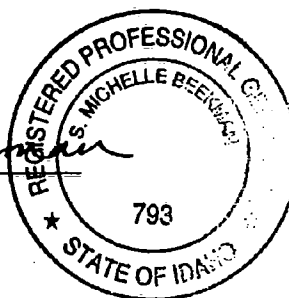
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**Final Site Investigation Report/
Remedial Action Plan
Boise Towne Square Mall
Boise, Idaho**

This document was prepared for the sole use of Van Waters & Rogers Inc. (VW&R) in meeting the requirements of the Boise Towne Square Mall Consent Order between VW&R and the Idaho Department of Health and Welfare, Division of Environmental Quality. No other party should rely on the information without the prior written consent of HLA and VW&R.

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DISTRIBUTION

EXECUTIVE SUMMARY

Van Waters & Rogers Inc. (VW&R) operated a chemical warehouse and distribution facility in Boise, Idaho, from approximately 1973 to 1983. A 6,000-gallon above ground storage tank (AST) used to store perchloroethylene (PCE) was located at the former facility. A Pier 1 Imports store currently occupies the general area where the warehouse was located. The store is located at 140 Milwaukee Avenue, Boise, Idaho. The Pier 1 Imports store is part of the Boise Towne Square Mall (Mall).

Subsurface investigations began at the Mall and vicinity of the Mall in approximately 1988. The investigations indicated the presence of volatile organic compounds (VOCs) in soil and groundwater adjacent to and downgradient of the former PCE AST.

VW&R and the Idaho Department of Health and Welfare, Division of Environmental Quality (Department) executed a Consent Order effective as of October 9, 1992 (Boise Mall Order) which requires investigation and, if necessary, remediation of the site. The site includes the Mall, including the area around the Pier 1 store. This Site Investigation Report/Remedial Action Plan (SI/RAP) describes the results of the site investigation (SI) activities and presents an evaluation of remedial alternatives for the site.

The purpose of the SI was to assess the nature and extent of VOCs in soil, soil gas, and groundwater; identify potential migration pathways and potential receptors; and evaluate the potential risk to human health and the environment from site-related VOCs.

The purpose of the remedial action evaluation was to develop remedial goals; identify, screen, and evaluate remedial technologies considered applicable to the site-specific conditions; and develop appropriate remedial alternatives.

Site Investigation

SI activities included a soil gas investigation, groundwater sampling, pilot boring and

monitoring well installation, geophysical investigation, monitoring/extraction well installation, data validation, and data management. The SI activities were conducted in accordance with Department-approved work plans, a Quality Assurance Project Plan (QAPP), and a Site Safety Plan. Each of these plans was prepared prior to initiating the SI and was reviewed and approved by the Department.

The findings of the SI have been integrated with the data available from the preceding site characterization studies. Based on these integrated data, the characteristics and features of the site relevant to the SI process have been summarized. The site characteristics and features relevant to the SI include site geology and hydrogeology, soil quality, groundwater quality, potential migration pathways, and potential risk to human health and the environment.

Site Geology and Hydrogeology

Based on the integration of all the data available from project-specific borings and a review of regional geology, the geology and hydrogeology beneath the site are summarized as follows:

- The stratigraphy beneath the site consists of approximately 3 to 5 feet of silty clay fill underlain by gravel and sand mixtures, silt, or clayey sand to an approximate depth of 11 feet. Sand and gravel underlie the finer materials to an approximate depth of 70 feet. The sand and gravel are hard-packed between depths of approximately 14 and 48 feet. Silty sand with gravel underlies the sand and gravel to an approximate depth of 93 feet. Sand was encountered between 93 and 96 feet below ground surface (bgs). Low permeability layers consisting of interbedded clayey silt and sand underlie the sand in the vicinity of the Pier 1 store to an approximate depth of 100 feet. Silty clay was encountered beneath the clayey silt and sand to a depth of approximately 101 feet.

- Results of the seismic reflection survey confirm the depth of the lower permeability layers near the Pier 1 store and indicate the presence of another lower permeability layer at an approximate depth of 150 feet bgs. The seismic reflection survey indicated that the depth to a low permeability layer northwest of the Pier 1 store near the Olive Garden Restaurant deepens to approximately 160 feet bgs.
- The unconsolidated silt, sands, and gravels that comprise the shallow aquifer in the site vicinity are of Pleistocene Age and were deposited and reworked by the Boise River.
- The shallow aquifer beneath the site is unconfined. Groundwater levels fluctuate during the irrigation season (i.e., April through October). In general, depth to water ranges from approximately 10 to 15 feet bgs during the irrigation season, and from approximately 15 to 20 feet bgs during the nonirrigation season.
- Groundwater flows toward the north-northwest at a gradient ranging from approximately 0.001 to 0.003 ft/ft.

Soil Quality

Soil quality assessments conducted during and prior to the SI indicate the following:

- The most prevalent VOC detected in soil at the site was PCE. The highest detected concentration of PCE was present immediately adjacent to the former PCE AST location.
- Data collected in 1994 indicates that the existing soil vapor extraction (SVE) system has reduced the PCE concentrations in unsaturated soil to less than 0.5 mg/kg in the immediate vicinity of the former PCE AST, and to nondetectable concentrations in other areas of the site.

Soil above the water table is no longer considered to be a source of PCE at the site and, therefore, will not require any additional remediation.

Groundwater Quality

The following summary of groundwater quality conditions is based on monitoring data collected during and prior to the SI.

- The most prevalent VOCs in groundwater are PCE, TCE, and 1,2-DCE. Of these, PCE is considered to be the primary chemical of concern based on the site history, frequency of detection, areal and vertical extent, and concentration.
- The concentrations of PCE in shallow groundwater at the site are highest immediately downgradient of the former PCE AST location and decrease toward the northwest (downgradient).
- The vertical distribution of PCE is concentrated in the upper 40 feet of the shallow aquifer and is limited to the upper 100 feet of the shallow aquifer in the immediate vicinity of the former PCE AST, and to the upper 75 feet of the shallow aquifer downgradient of the former PCE AST.
- Hard-packed sand and gravel encountered in the upper 48 feet of the borehole for the monitoring/extraction well near the Pier 1 store appears to have served as a limited barrier to downward migration of PCE to deeper (i.e., greater than 50 feet) portions of the shallow aquifer.
- Based on the areal and vertical distribution of PCE in groundwater at the site, it appears that PCE is being transported primarily via advective flow and, to a lesser extent, via hydrodynamic dispersion.

Risk Assessment Summary

The results of the Risk Assessment indicated:

- Three chemicals of potential concern (COPCs) were identified: PCE, TCE, and 1,2 DCE
- The only complete exposure pathways identified for the site were inhalation of vapors from groundwater in both indoor and

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outdoor air; however, health risks quantified in the RA were found to be less than target risk criteria

- No complete pathways for ingestion of and dermal contact with soil, groundwater, or surface water are present at the site
- No ecological receptors are present at the site
- Cleanup levels (CLs) were not calculated because no need for remediation was identified to protect onsite receptors from inhalation of vapors from groundwater.

Remediation of the COPCs in groundwater is not necessary to protect human health or the environment with respect to the complete pathways identified for the site. Groundwater remediation will commence, nonetheless, to prevent migration of VOCs to downgradient locations where other types of exposure may occur to human and/or ecological receptors.

Remedial Action Plan

The scope of the RAP was consistent with the EPA's October 1988 guidelines for conducting feasibility studies and included the following:

- Development of remedial action objectives and proposed CLs
- Identification and initial screening of remedial technologies
- Secondary screening of remedial technologies
- Development and evaluation of remedial alternatives.

Remedial Action Objectives

Remedial action objectives are based on protecting human health and the environment and are site- and medium-specific. The environmental medium considered for remediation is groundwater. The groundwater at the site is not considered to be a drinking water source and, therefore, does not pose a risk to human health or the environment with regard to complete exposure pathways identified at the site

(e.g., inhalation of vapors in indoor and outdoor air). However, downgradient of the site the groundwater is a limited drinking water source. For this reason, it is anticipated that groundwater at the site will require some remediation. Proposed CLs are federal maximum containment levels (MCLs). These, however, may be modified based on the results of the risk assessment being conducted for the area downgradient of the site with the concurrence of the Department. Vadose zone soil beneath the site has been remediated and is not considered further in this RAP.

Identification and Initial Screening of Remediation Technologies

The identification and initial screening of remedial alternatives was based onsite-specific conditions and site-specific remedial objectives. Those remedial alternatives considered inappropriate were eliminated. The groundwater remediation alternatives screened included no action; physical and hydraulic containment; in situ chemical and biological treatment; in situ air sparging; and extraction/treatment. Treatment process options were air stripping, carbonaceous adsorbent, air stripping and carbonaceous adsorption, chemical/ultraviolet oxidation, and bio-oxidation. Groundwater remediation alternatives/process options retained for further consideration included no action, hydraulic containment, air sparging and vapor extraction, extraction and treatment by air stripping, and extraction and treatment by carbonaceous adsorption.

Secondary Screening of Remedial Technologies

The remedial alternatives retained for further consideration were evaluated in terms of effectiveness, implementability, and cost. The evaluation of effectiveness focused on achieving the CLs, the potential impact on human health and the environment during implementation, and reliability considering site-specific conditions and the remedial action objectives. The implementability criterion pertained to technical feasibility and institutional acceptance by the Department. Cost was addressed qualitatively as low, medium, or high.

On the basis of the secondary screening, groundwater remediation alternatives and process options retained for further consideration included no action and a combination of groundwater extraction and treatment using a carbonaceous adsorbent or air stripping, with air sparging and vapor extraction. These remedial technologies and process options are technically feasible, potentially effective, institutionally acceptable, and potentially cost-effective.

Evaluation of Remedial Alternatives

Consistent with EPA guidance and the Boise Mall Order, nine criteria were used for detailed analysis of the two remedial alternatives. These criteria were short-term effectiveness; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; cost; overall protection of human health and the environment;

compliance with applicable or relevant and appropriate requirements (ARARs); regulatory agency acceptance; and community acceptance.

The detailed evaluation showed that the no action alternative is not appropriate because it would not be effective in the long term; would not reduce the toxicity, mobility, or volume of VOC-containing groundwater; and would not comply with the ARARs for groundwater.

The detailed evaluation showed that air sparging and vapor extraction coupled with groundwater extraction and treatment using either carbonaceous adsorbent or air stripping would be effective in the long term, implementable, reduce potential excess risk to downgradient receptors, and comply with ARARs for groundwater. Additionally, this remedial alternative is expected to be acceptable to the Department and the community.

1.0 INTRODUCTION

This Site Investigation Report/Remedial Action Plan (SI/RAP) was prepared by Harding Lawson Associates (HLA) for Van Waters & Rogers Inc. (VW&R), Kirkland, Washington, for the Boise Towne Square Mall (Mall), Boise, Idaho (Plate 1). This SI/RAP describes the results of the SI activities at and in the vicinity of a former VW&R distribution facility in Boise, Idaho, and presents an evaluation of remedial alternatives for the site. This SI/RAP has been prepared to fulfill a condition of a Consent Order dated October 9, 1992 (Boise Mall Order), between VW&R and the State of Idaho Department of Health and Welfare, Division of Environmental Quality (Department; IDHW, 1992). The scope of work for the SI/RAP was presented in *Exhibit 3, Work Plan, Boise Towne Square Mall Supplemental Investigation and Final Remediation, Boise, Idaho* dated September 8, 1992 (HLA, 1992b). The SI/RAP addresses comments received from the Department (*Department, 1994b, 1994c*) on the draft Mall SI/RAP dated July 27, 1994. Copies of the Department's comment letters and a response letter (HLA, 1994c) are included in Appendix E. Appendix E also contain additional comments received from the Department dated December 22, 1994, (*Department, 1994d*) and from the City of Boise dated December 9, 1994 (*City of Boise, 1994*) on the Draft Final SI/RAP, and a copy of HLA's response letter.

The original scope of work proposed separate documents for the SI and RAP. In the interest of timely implementation of proposed remedial actions and with the approval of the Department, these deliverables have been combined into one comprehensive document.

The purpose of the SI was to assess the nature and extent of volatile organic compounds (VOCs) in soil, soil gas, and groundwater; identify potential migration pathways and potential receptors; and evaluate the potential risk to human health and the environment.

The purpose of the remedial action evaluation was to develop remedial goals; identify, screen, and evaluate remedial alternatives considered applicable to the site-specific conditions; and develop appropriate remedial alternatives.

The area downgradient of the Mall is known as the Preliminary Study Area (PSA). The PSA is being evaluated under a separate consent order between VW&R and the Department.

This SI/RAP consists of text, tables and figures. Section 2.0 presents background information pertaining to the site history, SI activities conducted prior to October 9, 1992 (the effective date of the Boise Mall Order), and interim soil remediation. A description of the physical characteristics of the site is presented in Section 3.0. The SI activities and results are presented in Section 4.0. The nature and extent of the VOCs detected in soil and groundwater beneath the site are presented in Section 5.0. A summary of the Mall Risk Assessment is presented in Section 6.0. Section 7.0 presents the summary and conclusions of the SI. Section 8.0 describes the remedial action objectives, including a discussion of ARARs. Section 8.0 also includes the development of general response actions and the identification and initial screening of potentially applicable remediation technologies for groundwater. Section 9.0 describes the screening of remedial technologies retained for further consideration subsequent to the initial screening. Section 10.0 discusses the development of the remedial alternatives and presents a detailed evaluation of each. Section 11.0 presents the conceptual approach to implementing the chosen remedial alternatives. A schedule for implementation of the chosen remedial alternatives is presented in Section 12.0. References cited in this report are presented in Section 13.0.

2.0 BACKGROUND

2.1 Site Description and History

The site consists of the Boise Towne Square Mall building (Mall), parking lot surrounding the Mall, and other retail establishments associated with the Mall (Plates 1 and 2). From approximately 1973 to 1983, VW&R operated a small chemical distribution facility from a portion of a warehouse located on Friedly Drive, Boise, Idaho. A 6,000-gallon above ground storage tank (AST) used to store perchloroethylene (PCE) was located in an outdoor storage area at the eastern end of the former warehouse. Nielsen Transfer & Storage Co. (NT&S) also occupied a portion of the warehouse throughout the term of the VW&R lease. The property was apparently owned by a number of parties during VW&R's tenancy, including NT&S, Nielsen Warehousing Company, Montford Brooks, and Shirley O'Reilly (n/k/a Shirley O'Reilly Crowe).

An underground petroleum storage tank (UST) was reported by Price Development Corporation, Salt Lake City, Utah, to have been used at the warehouse site by NT&S and removed during mall construction (approximately 1988). In approximately late 1987 or 1988, the warehouse was removed under the direction of the Boise Mall Development Company or Price Development Corporation. A Pier 1 Imports store currently occupies the general area where the former warehouse partially occupied by VW&R was located. The current address of the Pier 1 Imports store is 140 Milwaukee Avenue, Boise, Idaho. The general location of the Pier 1 Imports store is referred to herein as the "140 Milwaukee Avenue Area". The Mall, Mall parking lot, and other retail establishments which are associated with the Mall occupy the area north, northeast, northwest, and west of the 140 Milwaukee Avenue Area. The 140 Milwaukee Avenue Area is bordered to the east by a bike path and freeway overpass and to the south by the Union Pacific Railroad and Franklin Road (Plate 1).

2.2 Previous Investigations

This section describes investigations conducted in the general vicinity of the site prior to the effective date of the Boise Mall Order (October 9, 1992). A summary of these investigations is presented in Exhibit 3 to the Boise Mall Order which is entitled *Exhibit 3, Work Plan, Boise Towne Square Mall Supplemental Investigation and Final Remediation, Boise, Idaho* dated September 8, 1992 (HLA, 1992b). Data was collected at or in the vicinity of the site as part of the following investigations:

- Site assessment of Mervyn's (in the Boise Towne Square Mall) conducted in March 1989 by Dames & Moore
- Soil sampling upgradient of and at the 140 Milwaukee Avenue Area in April and July 1989 by the Department
- Soil sampling in June 1989 by Geraghty & Miller, Inc. for VW&R
- Site assessment of the Pier 1 Imports store in June 1991 by Professional Service Industries, Inc. (PSI)
- Installation of four groundwater monitoring wells in the 140 Milwaukee Avenue Area vicinity in July 1991 by Chen-Northern for the Department
- Sampling of the groundwater monitoring wells in July and October 1991 by the Department
- Environmental site evaluation of the Mall conducted in August 1991 by GZA GeoEnvironmental, Inc. (GZA)
- Soil gas and groundwater investigation in the vicinity of the 140 Milwaukee Avenue Area conducted during September 1991 by HLA

- Soil investigation conducted during November 1991 by HLA
- Monitoring well sampling at the Mall in June 1992 conducted by Industrial Health Incorporated-Environmental (IHI).

A summary of each of the above investigations is presented in the following sections. Based on review and interpretation of available information, sampling, laboratory, and analytical methodologies used by various parties for identification and quantification of PCE in these investigations differ. Accordingly, the data obtained during these different investigations should be used qualitatively. Plate 2 presents the locations of wells sampled during these investigations and Table 1 presents PCE and other VOC concentrations detected in groundwater. Plates 3 and 5 present the soil boring locations, and Tables 2, 4, and 5 summarize the PCE concentrations detected in soil.

2.2.1 Mervyn's Parcel

During February 1989, Dames & Moore conducted a site assessment on the Mervyn's parcel at the Mall. Five monitoring wells (1, 2U, 2L, 3U, and 3L) were installed (two sets of which were deep/shallow well pairs) and sampled (Plate 2). Laboratory analytical results of groundwater samples collected from the wells indicated that no VOCs were detected in any of the wells (Table 1; *Dames & Moore, 1989*).

2.2.2 State of Idaho Soil Sampling

In April and June 1989, eleven shallow soil samples were collected by the Department from the area surrounding the 140 Milwaukee Avenue Area. One soil sample was collected from the 140 Milwaukee Avenue Area, just downgradient of the Pier 1 Imports store. The samples were analyzed for VOCs using EPA Test Method 502.2 (*Department, 1989*). The sample collected from the 140 Milwaukee Avenue Area contained PCE at a concentration of 0.67 micrograms per kilogram ($\mu\text{g/kg}$). No other VOCs were detected in any of the samples. Some samples collected in April 1989 were analyzed after their holding times had been exceeded at the analytical

laboratory resulting in reported values that may have been less than actual concentrations. Those sample locations were re-sampled and analyzed in June, 1989 within the allotted holding times yielding valid results.

2.2.3 Soil Sampling, June 1989

In June 1989, nine soil samples were collected from three soil borings by Geraghty & Miller, Inc. personnel for VW&R (*Geraghty & Miller, 1989*). The boring locations are shown on Plate 3. The borings were drilled to depths ranging from 11.5 to 12 feet and soil samples collected continuously throughout the boring for lithologic and chemical analysis. The samples were analyzed for VOCs using EPA Test Method 8240.

PCE was detected in six of the nine samples at concentrations ranging from 0.11 milligrams per kilogram (mg/kg) to 17 mg/kg (Table 2). 1,2-dichloroethene (total) (1,2-DCE) was detected in two soil samples at concentrations of 3.1 mg/kg and 0.17 mg/kg. Trichloroethene (TCE) was detected in three samples at concentrations ranging from 0.05 to 1.7 mg/kg. Toluene was detected in five samples at concentrations ranging from 0.11 to 0.13 mg/kg. Toluene was also detected in the laboratory reagent blank at a concentration of 0.05 mg/kg, indicating that it was likely introduced to the soil samples at the laboratory during analysis.

2.2.4 Pier 1 Environmental Assessment

A Phase 1 environmental site assessment was conducted in June 1991 for Pier 1 Imports (U.S.), Inc. at the Pier 1 Imports store by Professional Service Industries, Inc. (*PSI, 1991*). The site assessment consisted of reviewing available environmental information regarding the site vicinity and conducting an onsite reconnaissance. No soil or groundwater samples were collected during PSI's investigation. PSI concluded that the site where the Pier 1 Imports store is now located was suspected by the Department to be the point of origination of PCE contamination known to be present in the area. PSI recommended to Pier 1 that a subsurface investigation be conducted at the site.

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2.2.5 State of Idaho Well Installation

To assess the groundwater quality in the vicinity of the Pier 1 store, four groundwater monitoring wells (State MW-1 through State MW-4) were installed by Chen-Northern, Boise, Idaho, in July 1991, for the Department (Plate 2) (*Chen Northern, 1991*). The Department subsequently sampled the monitoring wells and submitted the samples for chemical analysis of VOCs using EPA Test Method 502.2. The laboratory analytical results are shown in Table 1. Results indicated that PCE was present in the samples at concentrations ranging from nondetectable (ND) to 656 micrograms per liter ($\mu\text{g/l}$) (*Conde, 1991*). Other detected VOCs include *cis*-1,2-DCE and 1,1,1-trichloroethane (1,1,1-TCA). Samples collected by the Department in October 1991 from Wells MW-1 and MW-2 contained PCE at concentrations of 7,370 $\mu\text{g/l}$ and 6,350 $\mu\text{g/l}$ in the duplicate samples from MW-1; PCE was not detected in the sample from MW-2. *Cis*-1,2 DCE and TCE were also detected in MW-1 at concentrations of 16.8 $\mu\text{g/l}$ and 21.3 $\mu\text{g/l}$, respectively, and in the duplicate sample at 16.5 $\mu\text{g/l}$ and 23.4 $\mu\text{g/l}$, respectively (Table 1).

2.2.6 GZA Site Investigation

In June 1991, GZA completed an environmental site investigation for the O'Connor Group, New York, New York, to characterize soil and/or groundwater quality conditions on the Mall Property. As part of this investigation, GZA installed and sampled six groundwater monitoring wells (GZA-1 through GZA-6) (Plate 2). GZA screened the samples for VOCs using a gas chromatograph and a static headspace technique that is not an approved EPA analytical method. Analytical results of samples collected from the six wells, along with two of the Department's wells (Wells MW-1 and MW-2) sampled by GZA, indicated that PCE was detected in five of the eight samples at concentrations ranging from 56 to 2,500 $\mu\text{g/l}$ (Table 1; *GZA, 1991*).

2.2.7 140 Milwaukee Avenue Area Soil Gas and Groundwater Investigation

HLA conducted a soil gas and groundwater investigation for VW&R between September 12 and 17, 1991 to assess: (1) the potential for the former VW&R facility to be a source of PCE in soil and groundwater, (2) the potential for the existence of other sources of PCE, and (3) the horizontal extent of PCE in the immediate vicinity of the 140 Milwaukee Avenue Area (*HLA, 1991b*). Activities included measuring water-levels in the four Department monitoring wells (Wells MW-1 through MW-4), collecting and analyzing groundwater samples from Wells MW-1 and MW-2 for halogenated VOCs using EPA Test Method 8010, and conducting a soil gas survey for halogenated and aromatic VOCs using EPA Test Method 8021. Soil gas sampling locations and analytical results are shown on Plate 2.

Groundwater elevations in the four Department wells ranged from 2686.34 to 2687.01 feet mean sea level (MSL), and the direction of groundwater flow was toward the west/northwest at an approximate gradient of 0.001 to 0.003 ft/ft (*HLA, 1991b*). Groundwater samples collected from Well MW-1 contained PCE, TCE, and 1,2-DCE (*cis* and *trans*) at concentrations of 5100, 70, and 63 $\mu\text{g/l}$, respectively. Groundwater from Well MW-2 contained PCE and 1,1,1-TCA at concentrations of 6.1 and 2.0 $\mu\text{g/l}$, respectively (Table 1).

PCE was detected at concentrations ranging from 0.11 to 5,500 $\mu\text{g/l}$ in 25 of 34 soil gas samples (Table 3). TCE was detected in 18 soil gas samples at concentrations ranging from 0.02 to 1,800 $\mu\text{g/l}$. *Cis*-1,2-DCE was detected in 10 soil gas samples at concentrations ranging from 0.6 to 540 $\mu\text{g/l}$. Vinyl chloride and *trans*-1,2-DCE were detected in 2 soil gas samples at concentrations of 5.8 and 3.3, and 2.2 and 0.71 $\mu\text{g/l}$, respectively. Ethylbenzene was detected in 10 soil gas samples at concentrations ranging from 2 to 1,200 $\mu\text{g/l}$.

2.2.8 140 Milwaukee Avenue Area Property Soil Boring Investigation

To confirm the presence and concentration of chemical constituents detected during the soil gas survey (HLA, 1991b), evaluate the potential for other VOCs to be present in soil, and to provide data to assist in the design of a soil vapor extraction (SVE) system, four soil borings were drilled in the 140 Milwaukee Avenue Area for VW&R under HLA's direction on October 22, 1991 (HLA, 1991c). Two borings were drilled in the vicinity of the former PCE AST location, one was drilled at the southeast corner of the 140 Milwaukee Avenue building, and one was drilled approximately 220 feet downgradient (west-northwest) of the former AST location (Plate 3). The borings were drilled to approximately 1 foot below the water table at depths ranging from 13.5 to 14.5 feet and soil samples were collected for lithologic characterization and chemical analysis at approximately 2-foot intervals. The samples were analyzed for halogenated and aromatic VOCs using EPA Test Methods 8010/8020 and for total petroleum hydrocarbons (TPH) as gasoline and diesel using EPA Test Method 8015 (modified). The samples were also analyzed for moisture content.

Table 4 presents a summary of the analytical results; complete analytical results are included in Appendix A. The data indicated that the highest concentrations of analytes were detected in samples collected between 4.5 and 8.5 feet bgs from Borings B-1 and B-2, drilled in the immediate vicinity of the former AST location. PCE was detected in all soil samples at concentrations ranging from 0.014 to 26,000 mg/kg (Table 4). TCE was detected in four samples collected from Borings B-1 and B-2 at concentrations ranging from 0.4 and 3.1 mg/kg. Methylene chloride was detected in all but two samples at concentrations ranging from 0.16 to 1.1 mg/kg. Carbon tetrachloride was detected at a concentration of 0.18 mg/kg in the sample collected from Boring B-1 at a depth of 9.5 feet. Cis-1,2 Dichloroethene was detected in three samples collected from Borings B-1 and B-2 at concentrations ranging from 0.014 to 1.3 mg/kg. The soil sample collected from boring B-3 at a

depth of 8 feet contained 1,1,1-TCE at a concentration of 0.016 mg/kg.

TPH were not detected in any of the samples. Moisture contents by weight ranged from 3.5 to 18 percent.

2.2.9 IHI Monitoring Well Sampling

In June 1992, IHI, Salt Lake City, Utah, sampled six existing monitoring wells installed by GZA on the Mall Property. The sampling was performed on behalf of the Boise Mall Development Company and Price Development Company. Analytical results of samples collected from the six GZA wells indicated that PCE was detected in three of the six samples at concentrations ranging from 400 to 2,500 $\mu\text{g/l}$ (IHI, 1992). TCE and cis-1,2 DCE were detected in the sample collected from GZA-4 at concentrations of 45 and 150 $\mu\text{g/l}$, respectively (Table 1).

2.3 Interim Remediation

2.3.1 Soil Vapor Extraction System Installation

As an interim source control measure for PCE-contaminated soil in the vicinity of the former VW&R distribution facility, VW&R installed and has continued to operate a soil vapor extraction (SVE) system as described in the *Work Plan, Pilot Soil Vapor Extraction System, Former VW&R Facility, Boise, Idaho*, dated January 24, 1992 (VW&R, 1992). The location of the SVE is shown on Plate 4. The SVE system recovers VOCs from the soil and to a lesser degree, from groundwater. Recovered vapors are adsorbed onto activated carbon. Application of the SVE system to contaminated soils has minimized the potential for future groundwater contamination resulting from dissolution of PCE and other VOCs adsorbed onto the soil to seasonally fluctuating groundwater levels or soil pore water. The SVE is operated under an air permit issued by the Department (IDEQ, 1991).

Installation of the SVE began on February 25, 1992. One component of the installation involved the placement of both perforated and

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blank PVC piping into the soil to collect and move the subsurface vapors to the treatment system. During installation of the underground piping, soils were excavated from trenches to depths ranges from 5.5 to 7.0 feet below ground surface (bgs). The soils were sampled and analyzed using EPA Test Methods 8010 and 8020 to determine the type and concentration of VOCs present in the soils and to determine appropriate soil disposal procedures. Soils with listed or characteristic waste qualities were disposed as a hazardous waste at the USPCI Grassy Mountain licensed hazardous waste disposal facility in Clive, Utah.

The SVE system is a self-contained, trailer-mounted, modular unit, that consists of a positive displacement blower, activated carbon canisters, and associated controls. The positive displacement blower provides for an adjustable vacuum at the vapor recovery wellhead of between 0 and 4 inches of mercury. This variable vacuum suction allows for adjustment to assure optimum air movement in the subsurface.

The extracted vapors are routed through dual activated carbon canisters operated in series. These canisters are designed to operate at three feet per second linear velocity or less. The adsorptive media is Cameron Yakima activated carbon, sieve size 4x6.

Sampling ports are provided so that system efficiency and air influent and effluent quality can be monitored. An additional sampling port is located between the carbon beds.

The module operates under positive ventilation to prevent the buildup of vapors inside the unit. Ventilation fans are interlocked through the control panel with the blower such that the blower will not operate unless the module ventilation fans are operating.

The horizontal perforated PVC piping was placed in trenches at a depth of approximately 7 feet bgs to optimize vapor removal from the zone of soil contamination with the highest measured VOC concentrations. Piping placement at this depth also prevents groundwater intrusion. The trenches are located to the north and east of the

Pier 1 Imports store at locations where high soil gas vapors and VOCs from soil samples were detected.

The vapor recovery system modular unit is connected to the horizontal vapor extraction piping using PVC piping. At five locations along the horizontal vapor extraction piping, traffic-rated utility boxes containing a valve and sampling port are located so that air flow rate from different sections of the vapor extraction piping can be sampled, balanced, and controlled.

Three vapor monitoring wells were installed at approximate distances of 5, 15, and 30 feet from the east "leg" of the vapor extraction piping (Plate 4). The vapor monitoring wells were drilled to an approximate depth of 7 feet bgs and are housed inside traffic-rated vaults. The vapor wells are monitored daily for vapor concentrations.

2.3.2 Evaluation of SVE System Effectiveness

To evaluate the effectiveness of the SVE system, five soil borings were drilled in the vicinity of the former PCE AST location near the Pier 1 Imports store on February 23, 1994 (Plate 5). The results of the soil boring program were presented in the January through March 1994 Quarterly Progress Report (HLA, 1994a). The borings were drilled using a truck-mounted hollow-stem auger drill rig to maximum depths of 18 feet (to the top of the water table). Soil samples were collected for lithologic characterization and chemical analysis at approximately 2-foot intervals using a 2-inch diameter split spoon sampler lined with brass tubes. Samples were visually inspected and screened with an organic vapor meter (OVM) for volatile organic vapors. Prior to field screening, one of the sample tubes from the sampling interval was sealed with plastic caps, labelled and placed in a chilled cooler. Two samples from each boring were selected for chemical analysis. The samples were shipped overnight to Analytical Technologies, Inc. (ATI), Renton, Washington, for analysis of halogenated and aromatic VOCs using EPA Test Methods 8010 and 8020. The samples were also analyzed for

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total organic carbon (TOC). Analytical results are summarized in Table 5. Complete analytical results are presented in Appendix A.

PCE was detected only in the samples collected from Boring B9405 at depths of 3.5 feet and 5.5 feet at concentrations of 0.11 and

0.088 milligrams per kilogram (mg/kg), respectively. A groundwater extraction/monitoring well (discussed in Section 4.6) was installed at the same location as Boring B9405. No other compounds were detected in any of the soil samples. TOC concentrations ranged from 0.02 to 0.12 percent.

3.0 PHYSICAL CHARACTERISTICS

This section describes the physical characteristics of the site and vicinity. These characteristics include climate; ecology; regional geology and hydrogeology; and land uses, demographics, and well inventory.

3.1 Climate

The Boise Valley has a dry climate that is characterized by cool, wet winters and warm dry summers. The mean annual precipitation in Boise is 11.42 inches, with only 25 percent occurring during the freeze-free growing season. Part of the winter precipitation is in the form of snow, but the snow generally melts quickly in the Boise Valley. Heavier snow of longer duration generally falls in the mountains north of Boise. The mean annual maximum daytime temperature in Boise is 51.3°F. January has the lowest mean monthly temperature and July the highest, with maximums over 100°F during a few days every summer (*Dion, 1972*). Winds are predominantly from the southeast and average 8.9 miles per hour (*Commerce, 1983*). Because of the dry climate in the Boise Valley, humidity is relatively low and averages 58 percent, with irrigated areas averaging slightly higher (*Dion, 1972*).

3.2 Ecology

The site is almost entirely asphalt paved or covered by buildings with foundations. The only vegetated areas are small landscaped islands in the parking area (Plate 2). The area is not inhabited by threatened or endangered species, and no habitat exists at the site for ecological receptors. Surface water bodies, other than storm runoff, are not present at the site. Stormwater runoff drains to two retention ponds north of the Mall (Plate 2).

3.3 Regional Geology and Hydrogeology

The shallow geology in the vicinity of the site consists of 50 to 150 feet of unconsolidated silt, sand, and gravel of Pleistocene Age, referred to as

older terrace gravels, that have been reworked and deposited by the Boise River (*Dion, 1972*). These older terrace gravels comprise the shallow aquifers in the area. Underlying and separated from the older terrace gravels by an unconformity is the Glenss Ferry Formation of Late Pliocene to Early Pleistocene Age. The Glenss Ferry Formation is composed of interbedded clay, silt, sand, fine gravel, and basalt up to 2,000 feet thick (*Dion, 1972*).

The water table in the site vicinity currently exists at an approximate depth of 8 to 15 feet below ground surface (bgs) and extends to depths ranging from 50 to 150 feet bgs. Localized groundwater recharge and discharge vary seasonally. Recharge generally occurs from the Ridenbaugh Canal, Farmers Lateral south of the site, and irrigation in the vicinity of the site between April and October. Localized groundwater discharge to the Finch Drain (previously known as the South Slough) in offsite downgradient areas has been observed. Although water levels and flow direction may fluctuate with the irrigation season, the predominant regional flow direction in the shallow aquifer is to the northwest. The presence of an aquitard separating the upper aquifer from the lower Glenss Ferry aquifer system is unconfirmed for the West Boise Area. However, data from well logs suggest that aquitards or lower permeability units are laterally discontinuous in the West Boise area.

Hydraulic characteristics of the water table aquifer in the vicinity of the site are not known; however, short duration pumping tests have been conducted in the water table aquifer approximately ¼ mile downgradient of the site by Special Resources Management (SRM). Results of this testing indicated that transmissivity values for wells having depths of 41 feet to 47 feet ranged from 11,475 gallons per day per foot (gpd/ft) to 43,000 gpd/ft. A storativity value of 0.03 was obtained and is based on data collected during a 12-hour pumping test (*SRM, 1989*).

A deeper confined aquifer system exists in the sand, gravel, and basalt of the Glenns Ferry Formation (*Mink and LeBaron, 1976*). The deep aquifer is recharged primarily from infiltration of precipitation and snowfall along the foothills and ridge areas and potentially from the shallow aquifer. Groundwater removal from the aquifer is primarily from the Boise Water Corporation for domestic and industrial use. Aquifer studies indicate a transmissivity of approximately 16,000 gallons per day per foot and a storage coefficient of 0.02 (*Mink and LeBaron, 1976*).

3.4 Land Uses, Demographics, and Well Inventory

The current and expected future land use and zoning for the site is commercial. Adult workers

including construction, maintenance, and other commercial workers (e.g., sales personnel and cashiers), and visitors and shoppers, including children and adults, are present at the site. Land uses north and northwest of the site (downgradient and offsite) are commercial, residential, and agricultural; offsite populations include residents and office/commercial workers. Commercial land use appears to be increasing throughout the vicinity while single family residential and agricultural land uses are decreasing. A well inventory shows that no wells at the site are currently used for residential, agricultural, commercial or industrial purposes; water used at the site is supplied by Boise Water Corporation (*HLA, 1994b*).

4.0 SITE INVESTIGATION

In addition to the preliminary soil and groundwater investigations discussed in Section 2.2, a number of additional investigations were performed after the effective date of the Boise Mall Order. This section summarizes these SI activities. All of these investigations were conducted in accordance with the Department-approved Mall Work Plan (HLA, 1992b). The Mall Work Plan is Exhibit 3 to the Boise Mall Order. Descriptions and results of each activity have been reported to the Department in previous documents which are referenced herein. SI activities included a soil gas investigation, groundwater sampling, pilot boring and monitoring well installation, geophysical investigation, monitoring/extraction well installation, data validation, and data management.

4.1 Project Plans

SI activities were performed in accordance with the Mall Work Plan (HLA, 1992b). Where activities differed from those described in the Work Plan, approval was first received from the Department. Field investigative methods and data evaluation followed procedures detailed in the Quality Assurance Project Plan (QAPP; HLA, 1992c). The QAPP describes the quality assurance and quality control (QA/QC) procedures used to document that the technical data generated during the investigation are accurate, precise, complete, and representative of actual field conditions. A Site Safety Plan detailing health and safety procedures for use during the project was also prepared and followed (HLA, 1991a).

4.2 Supplemental Soil Gas Investigation

4.2.1 Field Program

To further evaluate the extent of PCE and its degradation compounds in soil gas, evaluate the potential for other sources, and qualitatively evaluate the extent of PCE and its degradation compounds in groundwater, HLA supervised a

soil gas survey at the site between November 11 and 13, 1992. The results of the soil gas investigation were reported in the Supplemental Pilot Boring Sampling and Analysis Plan (HLA, 1993a). The survey was conducted by Hydro Geo Chem, Inc., Tucson, Arizona, under contract to HLA and VW&R.

Soil gas samples were collected from 31 sampling points determined in part by using a grid system with 100-foot by 100-foot spacing (Plate 2). Samples were immediately transported to an onsite mobile laboratory where they were analyzed for halogenated and aromatic VOCs using EPA Test Method 8021. A description of the gas chromatographic procedure used by the mobile laboratory is included in Appendix B.

Prior to sampling on each day and following equipment decontamination, atmospheric field blanks were collected and analyzed to check background contamination in the sampling system and cartridges. In addition, duplicates from six sampling locations were analyzed as a measure of reproducibility.

4.2.2 Soil Gas Results

Appendix C presents the measured soil gas concentrations from each sampling location. Plate 2 presents PCE soil gas concentrations detected during this investigation. PCE was detected in 28 of the 31 sampling locations at concentrations ranging from 0.16 to 1,463 $\mu\text{g/l}$. The detection limit for all compounds was 0.01 $\mu\text{g/l}$. TCE was detected in 18 samples at concentrations ranging from 0.04 to 74 $\mu\text{g/l}$. Trans-1,2-DCE was detected in 4 samples at concentrations of 0.02 to 0.87 $\mu\text{g/l}$. Cis-1,2 DCE was detected in five samples at concentrations ranging from 0.57 to 20 $\mu\text{g/l}$. Vinyl chloride was detected in two samples, SG-28 and SG-31, at concentrations of 1.24 and 0.53, respectively. Concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX), ranging from 0.03 $\mu\text{g/l}$ to 1.0 $\mu\text{g/l}$, were reported in several samples collected throughout the survey area. No anomalous PCE soil gas concentrations

indicating additional source areas within this study area were detected.

4.2.3 Data Validation

Equipment blanks were collected and analyzed each day following equipment decontamination. Trip blanks were also collected and analyzed each day. Equipment and trip blanks were used to detect potential contamination introduced during the field activities. The equipment and trip blanks were analyzed using the same procedures as the soil gas samples. Three equipment blanks were analyzed during this investigation. The equipment blanks collected on November 11 and 13, 1992, did not contain any of the target analytes. The equipment blank collected on November 12, 1992, contained m&p xylenes at a concentration of 0.19 µg/l. Samples that were analyzed on November 12, 1992, containing detectable concentrations of m&p xylenes that were less than five times the concentration detected in the equipment blank have been qualified as nondetect.

Three trip blanks were analyzed; the samples analyzed on November 12 and 13, 1992, did not contain any of the target analytes. The trip blank analyzed on November 11, 1992 contained PCE at a concentration of 2.0 µg/l. Samples analyzed on November 11 that contained PCE at less than 10 µg/l (five times the concentration detected in the trip blank) were qualified as nondetect.

To evaluate the precision of the field and analytical procedures, duplicate soil gas samples were collected and analyzed from sample locations SG-03, SG-04, SG-07, SG-19, SG-21, and SG-25. Relative percent differences (RPDs) were calculated using the following equation:

$$RPD = \frac{X_1 - X_2}{\bar{X}} \times 100$$

RPDs for PCE ranged from 7 to 86 percent. The average RPD for all 6 duplicate samples was 26 percent, indicating good reproducibility of data. All RPDs met the goals established in the QAPP (HLA, 1992c).

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4.3 Baseline Groundwater Sampling

To evaluate the extent of PCE in groundwater downgradient of the site in the PSA as part of the PSA investigation, groundwater sampling was conducted from February 22 through 26, 1993. The results of the sampling effort were reported in the January through March 1993 Quarterly Progress Report (HLA, 1993c). As part of that sampling effort, depth to water was measured and samples collected from one State well (State MW-3) and in two GZA wells (GZA-4 and GZA-6). Two of the State wells (State MW-1 and MW-4) were covered with snow and could not be located. State Well MW-2 was dry.

Groundwater samples were collected from the State and GZA wells after a minimum of three well volumes of water were removed or until the well was dry then recovered. A PVC bailer was used to purge the monitoring wells; a stainless steel bailer was used to collect the groundwater samples. The samples were placed in sample containers appropriate for the requested analyses. The water samples were transported to ATI, Renton, Washington, where they were analyzed for VOCs using EPA Test Method 8010.

Appendix D presents the groundwater analytical results. Results indicated that VOCs were not detected in the sample collected from State MW-3. PCE was detected in both GZA-4 and GZA-6 at concentrations of 3,000 µg/l and 360 µg/l, respectively. TCE was detected in both wells at concentrations of 13 and 1.9 µg/l, respectively. The sample collected from GZA-4 contained cis-1,2 DCE at a concentration of 40 µg/l. The sample collected from GZA-6 contained 1,1 DCE and 1,1,1 TCA at concentrations of 1.6 and 0.2 µg/l, respectively.

4.4 Pilot Boring Program

To gather data to assist in the characterization of hydrogeologic conditions at the site and to provide information on the vertical distribution of PCE, VW&R conducted a pilot boring investigation. The scope of work for the pilot boring program was originally presented in the *Supplemental Pilot Boring Sampling and Analysis Plan, Mall, Boise, Idaho* (Pilot Boring SAP), dated February 9, 1993 (HLA, 1993a), and consisted of

drilling two pilot borings, collecting groundwater samples from the borings for vertical chemical profiling, completing the borings as groundwater monitoring wells, collecting and analyzing groundwater samples from the wells, and conducting a geophysical pilot study (described in Section 4.5).

The results of the pilot boring program were presented in a letter report from HLA to VW&R dated May 11, 1993 (HLA, 1993e); the letter was copied to the Department. Two borings were drilled using air casing hammer drilling techniques: MW-1 is located in the parking lot north of the Olive Garden restaurant and MW-2 is in the parking lot approximately 73 feet northeast of the State Well MW-1, north of the 140 Milwaukee Avenue area (Plate 2). The original scope of work for the Pilot Boring program included collecting Hydropunch™ samples at approximately 20-foot intervals. However, field conditions encountered prohibited the use of the Hydropunch™ (i.e., gravels were encountered in the boreholes and the Hydropunch™ could not be driven into the formation for groundwater sample collection). Therefore, as the borings were advanced, groundwater samples (grab groundwater samples) were collected using a stainless steel bailer lowered through the casing to the bottom of the boring at intervals where formation heaving problems were not encountered. Grab groundwater samples were collected from the boring for Well MW-1 at depths of 58 and 78 feet. Grab groundwater samples were collected from the boring for Well MW-2 at depths of 58 and 98 feet.

Following drilling, the borings were completed as groundwater monitoring wells. Although the total depth of the borings was 158 feet, heaving sands prevented installation of the monitoring wells to that depth. The total depth for Well MW-1 is 128 feet with a screened interval of 108 to 128 feet. Well MW-2 was completed at a total depth of 137 feet with a screened interval of 117 to 137 feet. During completion of Well MW-2, the upper 68 feet of steel casing used during drilling of the borehole was cemented in place. The presence of the steel casing should have no impact on the integrity of the well or quality of groundwater samples collected from the well.

The wells were sampled on April 21 and 22, 1993, and analyzed by ATI for halogenated and aromatic VOCs using EPA Test Methods 8010 and 8020.

The analytical results for the pilot boring grab groundwater samples and samples from the completed wells are presented in Appendix D. Analytical results for grab samples collected from the boring for MW-1 indicate that PCE was detected in the 58- and 78-foot samples at concentrations of 650 and 1 µg/l, respectively. The sample collected from the completed Well MW-1 did not contain PCE. Grab samples collected from the boring for MW-2 indicate that PCE was detected at a concentration of 2.1 µg/l in the 58-foot sample and was not detected in the 98-foot sample nor in the sample collected from the completed well.

4.5 Geophysical Pilot Study and Well Logging

The scope of work for the geophysical pilot study and borehole logging was described in the *Supplemental Pilot Boring Sampling and Analysis Plan, Mall, Boise, Idaho* dated February 9, 1993. The objective of the study was to gather preliminary data to assist in the characterization of hydrogeologic conditions at the site. The preliminary data would be used, as necessary, to design a full-scale geophysical investigation at the site. To meet this objective, HLA conducted a seismic reflection pilot study. The results of the geophysical pilot study and well logging were presented in the *Geophysical Sampling and Analysis Plan* dated May 6, 1993 (HLA, 1993d).

The pilot study was conducted at three locations (two at the site and one at 1941 Five Mile Road in the PSA) and geophysical well logging in one well (MW-1 in the vicinity of the Olive Garden restaurant) during the week of April 12, 1993. The results of the pilot study conducted in the PSA will be reported in the PSA site investigation report.

4.5.1 Geophysical Logging

Downhole geophysical logging was conducted to provide additional information about subsurface lithologies, seismic velocities, and quality control

for the lithologic logging. Two geophysical logging techniques, natural gamma and EM conductivity, were utilized in Well MW-1 (Plate 2). Well MW-1 is constructed of Schedule 40 PVC casing and screen and has a total depth of 128 feet. Steel centralizers spaced at 20-foot intervals were used during well construction to stabilize the 4-inch-diameter PVC well inside the 14-inch-diameter boring.

A natural gamma log was completed using a Mount Sopris Instruments Model II system equipped with a stratigraphic probe. The well was logged downhole to determine optimum scales for the final uphole run. An EM conductivity log was also completed using a Geonics Ltd. Model EM39 electromagnetic borehole conductivity logger. The probe uses a focusing coil that enables the measurement of the conductivity of the soil within a distance of 20 cm to 100 cm from the well axis while being insensitive to the conductivity of the borehole fluid and the disturbed material situated near the well axis.

The natural gamma log for Well MW-1 indicates moderately high to high clay content in the sand and gravel from the surface to 36 feet bgs; clean sands and gravels (low clay content) from 36 to 117 feet bgs except for two thin (less than 5 feet thick) silty lenses at 58 and 75 feet. Below 117 feet bgs the clay content in the gravelly sands increases at approximately 125 feet bgs.

The EM conductivity log generally supports the above interpretation with the exception of an indication of an additional clayey sand lens at approximately 112 feet bgs.

4.5.2 Seismic Reflection Pilot Study

Seismic reflection testing was performed at two locations within the site using an EG&G Geometrics Model ES-2401 exploration seismograph and either 24 or 48 groups of 3 Mark Products, 40-Hz, L28E geophones spaced at 2- or 4-foot intervals (Plate 2).

For test line 1, located in the grass strip north of the Olive Garden restaurant, 48 geophone groups were positioned at 4-foot intervals. The test was

completed using three seismic energy sources: a 16-pound sledgehammer striking an aluminum plate on the grassy surface; a 12-gauge, 165 grain blank shotgun shell percussion rod placed at an approximate depth of 1.5 feet in the grass strip; and a 16-pound sledgehammer directly on the asphalt and offset approximately 10 feet from the geophone spread. Shotpoints were positioned at 2, 4, 190, and 192 feet east of the last geophone and provided data at 2-foot intervals. During data collection activities, filters were used to evaluate optimum recording parameters.

A common depth point (CDP) profile survey was also performed at test line 1 by positioning sledgehammer and plate shotpoints at 2-foot intervals between 192 feet east and 50 feet east of the end geophone.

For test line 2, located near Well MW-2, 24 geophone groups at 4-foot intervals were placed directly into holes punched in the asphalt parking lot. To complete the test, the sledgehammer was pounded directly on the asphalt at 4, 98, 190, and 282 feet west of the end geophone. Data were again recorded using filters to evaluate optimum recording parameters. No CDP profile was completed at test line 2.

The results of the seismic reflection profiling were generally consistent with the geophysical logs obtained from Well MW-1 and the lithologic logs compiled from grab sample data collected during the drilling of bore holes for Wells MW-1 and MW-2. Three energy sources were used during the seismic reflection survey; all three yielded high quality seismic data. A discussion of the results for the seismic reflection test at each location follows. It should be noted that all references to depths are estimates only.

Line 1 reflection data near the Olive Garden restaurant indicated no reflecting horizons within approximately the upper 160 feet. A reflecting horizon represents a change in lithology. A strong reflector may indicate the presence of a clay layer whereas a weak reflector may represent a more subtle change in lithology, such as from a coarse sand to a fine sand. A strong reflector was recorded at an approximate depth of 160 feet. A series of reflectors were recorded below 160 feet to a depth of approximately 400 to

450 feet. Comparison of the seismic data obtained from depths less than 158 feet with lithologic data obtained in Well MW-1 indicates that the seismic results are consistent with the lithologic log generated by the HLA field geologist. The lithologic log for the boring for well MW-1 was presented in the Pilot Boring Program Summary Letter dated May 11, 1993 (HLA, 1993e).

Because data generated from Line 1 were used to assist in determining the optimum recording settings and type of seismic source utilized, Line 2 reflection data collected on the asphalt near the Pier 1 Import store is the highest quality data recorded during the pilot study and possesses a greater resolution potential than data from Line 1 near the Olive Garden. Elimination of the CDP profile and reducing the number of geophone groups did not adversely impact the test results. Prominent reflecting horizons are evident at approximately 110- and 150-foot depths. A deeper series of reflectors extend to depths as great as 400 feet. Lithologic logs generated during drilling of MW-2 indicate an increase in fine sand at 151 feet but no change at the 110-foot depth.

4.6 Extraction Well Installation

To provide additional hydrogeologic and chemical data for the site, one soil boring was drilled and completed as a monitoring/extraction well near the former AST location at the 140 Milwaukee Avenue Area between February 24 and March 11, 1994, in accordance with procedures described in the Monitoring Well SAP (HLA, 1993b). The well location is shown on Plates 2 and 5. Initially, the well will be used for groundwater monitoring purposes; however, it was constructed so that it may be converted to an extraction well in the future, if appropriate.

The boring was drilled using cable tool methods. Drilling and well installation was conducted under the supervision of HLA and/or VW&R representatives. The boring was lithologically logged by an HLA geologist and a field log prepared. Soil cutting samples were collected at 5-foot intervals and/or at each observed change in lithology and classified in accordance with

ASTM D 2488-90, which is based on the Unified Soil Classification System. A description of the type of materials encountered during drilling is provided in Section 7.1. The lithologic log and well completion diagram was provided to the Department in the January through March 1994 Quarterly Progress Report (HLA, 1994a). Drilling ceased at a depth of approximately 101 feet due to the presence of a lower permeability unit consisting of a sandy clay. Stringers of sandy clay were observed beginning at a depth of approximately 96 feet.

The vertical distribution of PCE was assessed by collecting groundwater samples at discrete depths using a Hydropunch™ sampler during the drilling of the boring. Chemical data from the boring were used to determine target depths for well completion. Drilling proceeded to slightly above the target zone, the sampler was driven into the zone, and the sample inlet opened, allowing groundwater to flow into the sample chamber. Occasionally, lithologic conditions (e.g., the presence of gravel) prevented collection of groundwater samples with the Hydropunch sampler. At these locations, samples were collected by lowering a stainless steel bailer down the drill pipe to the bottom of the boring. The sampler or bailer was then brought to the surface and the sample poured from the sample chamber into a laboratory-provided volatile organic analysis (VOA) vial. Groundwater samples collected using a Hydropunch™ sampler are more representative of a specific depth than are the samples collected using a bailer. The bailer samples likely represent an average of the chemical concentrations throughout the entire water column. Target zones for collection of groundwater samples in the boring were at approximately 10-foot intervals throughout the boring.

Groundwater samples collected during drilling of the borehole were transported under chain of custody to Alchem Laboratory, Boise, Idaho, where they were analyzed for halogenated VOCs using EPA Test Method 8010 on an expedited 24-hour turnaround basis. Laboratory analytical results are shown in Appendix D. Detected PCE concentrations ranged from 24 µg/l at a depth of 95 feet to 20,400 µg/l at a depth of 40 feet. PCE concentrations in groundwater decreased from

20,400 $\mu\text{g/l}$ at 40 feet to 400 $\mu\text{g/l}$ at 50 feet suggesting that the hard packed sand and gravel in the upper 40 feet of the borehole act as a low permeability layer that inhibits the downward migration of PCE.

The well was constructed to an approximate depth of 84 feet using an 8-inch-diameter wire-wrapped stainless steel casing and screen. Because of the PCE concentrations detected in the groundwater samples collected from the boreholes, two distinct screened intervals were emplaced at depths of 19 to 44 feet bgs and 54 feet to 79 feet bgs. A 10-foot section of blank casing was grouted between the screened intervals. A filter pack was placed adjacent to and slightly above the screened intervals.

A straddle-packer was installed within the 10-foot section of blank (non-screened pipe) to isolate the upper screened interval from the lower screened interval, thereby inhibiting downward migration of PCE. Prior to well construction, construction details were discussed with and approved by the Department and the Idaho Department of Water Resources.

During the week of March 21, 1994, the upper screened interval of the well was developed. The well was developed by a combination of swabbing, surging, and pumping.

Groundwater samples were collected from the upper screened interval of the well on March 31, 1994, and transported under chain of custody to ATI, Renton, Washington, for chemical analysis of halogenated and aromatic VOCs using EPA Test Methods 8010 and 8020. The laboratory analytical results are shown in Appendix D. PCE was detected at concentrations of 20,000 $\mu\text{g/l}$ and 22,000 $\mu\text{g/l}$. Cis-1,2-DCE was also detected in both samples at concentrations of 2.1 $\mu\text{g/l}$ and 0.3 $\mu\text{g/l}$. Toluene was detected at a concentration of 3.3 $\mu\text{g/l}$. TCE was detected at concentrations of 28 $\mu\text{g/l}$ and 35 $\mu\text{g/l}$. 1,1,1-TCA was detected in one sample at a concentration of 0.3 $\mu\text{g/l}$ but was not detected in the duplicate sample. Because the surrogate percent recoveries were not within the control limits for both well samples due to matrix effects, all the sample results reported above are qualified as estimated.

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Decontamination and Waste Handling

To minimize the potential of cross-contamination, all drilling and sampling equipment used during each phase of the SI was decontaminated prior to and after use. Drilling equipment was steam cleaned prior to transport to the site and after drilling each boring. The soil and water sampling equipment was steam cleaned or washed in a low-phosphorous soap solution and double rinsed with water. All decontamination procedures were done in a manner which precluded a release of the cleaning solution to the environment.

Soil cuttings produced during drilling were contained in covered roll-off bins. Water produced during well development, sampling, and drilling was contained in a Baker tank. The Baker tanks and roll-off bins were stored onsite pending receipt of laboratory analytical data and approval for receipt by a licensed hazardous waste disposal facility.

4.8

Data Validation

Data validation was performed on all HLA and VW&R field and laboratory quality control (QC) samples. The validation results of individual field sampling events have been reported in previous referenced documents, except where noted herein. A description of QA/QC methods is provided below. Not all QA/QC procedures were required during every sampling activity. Where the data validation process indicated problems with either the field or laboratory QC, samples have been qualified accordingly in the database.

4.8.1

Field Quality Control

The field QC samples generally consisted of one or a combination of trip blanks, equipment blank, field blanks, and duplicate samples.

Trip blanks are prepared by the analytical laboratory and consist of organic-free deionized water in laboratory-prepared sample containers; they are not decanted from their original containers. Trip blanks are used to detect potential contamination introduced through field

or laboratory procedures; blanks are taken to the field and subjected to storage and transport conditions that are the same as those for groundwater samples.

Field blanks consist of organic-free deionized water poured into sample containers under field conditions. Field blanks are used to check for potential contamination during sample preparation in the field.

Equipment blanks consist of organic-free deionized water that is rinsed through decontaminated field sampling equipment and then poured into sample containers under field conditions. Equipment blanks are used to check for contamination resulting from inadequate decontamination procedures.

Duplicate samples are used to evaluate analytical laboratory precision. Precision is assessed by calculating the relative percent difference (RPD) between the initial sample result (X_1) and the duplicate sample result (X_2), as follows:

$$RPD = \frac{|X_1 - X_2|}{(X_1 + X_2)/2} \times 100$$

A low RPD indicates high precision.

4.8.2 Laboratory Quality Control

The laboratory quality control data consists of surrogate recoveries and blank spike recoveries.

Surrogate samples are prepared by the laboratory by adding surrogate compounds to field samples. Surrogate recovery goals were set in the QAPP (HLA, 1992c).

A blank spike is prepared in the laboratory by adding known amounts of target analytes to a field sample before laboratory preparation to simulate the matrix effect in analyses of field

samples. Percent recoveries are calculated for these target analytes as measures of the accuracy of the total analytical method. The spiked samples may also be analyzed in duplicate for an assessment of the analytical method. Blank spike recovery goals were set in the QAPP.

4.8.3 Overall Completeness

The data completeness value is a comparison of the number of data that meet QAPP accuracy and precision goals with the number of data that are expected to meet these goals. This value is calculated as follows:

$$C = \frac{V}{T} \times 100$$

where:

C = percentage of complete data for a parameter

V = number of valid results for a parameter (results that are within the acceptance criteria)

T = total number of sample results generated by a laboratory for a parameter.

4.8.4 Summary of Data Validation

All of the data generated during this site investigation have been validated in accordance with procedures described in the QAPP. Where appropriate, samples have been qualified in the database (Appendixes A, C, and D). Several samples have been qualified as estimated due to laboratory surrogate percent recoveries being out of compliance with the QAPP and as nondetect due to detections in trip and/or equipment blanks. No samples were qualified as rejected. Therefore, the data are considered to be accurate and precise and comply with the overall completeness criteria specified in the QAPP.

5.0 DISCUSSION

This section describes the site geology and hydrogeology and presents a discussion of the nature and extent of contamination based on the findings of the VW&R/HLA SI and earlier investigations conducted at the site.

5.1 Site Geology and Hydrogeology

5.1.1 Lithologies

Information regarding the shallow stratigraphy (i.e., above the water table) at the site was obtained from soil borings drilled during investigations conducted in October 1991 and February 1994 (HLA, 1991b and 1994). Information regarding the deeper stratigraphy at the site was obtained from borings drilled for the installation of monitoring and extraction wells in February 1993 and March 1994 (HLA, 1993e, 1994), and from the geophysical seismic reflection survey conducted at the site in April 1993 (HLA, 1993a).

A cross-section for the Site is shown on Plate 6. In general, a 3- to 6-inch-thick asphalt parking lot is underlain by approximately 3 to 5 feet of silty clay fill, which is underlain by gravel and sand mixtures, silt, or clayey sand to an approximate depth of 11 feet. Coarser sand and gravel underlie these materials to an approximate depth of 70 feet. The sand and gravel are hard packed and have a high silt or clay content between depths of approximately 14 to 48 feet. Silty sand with gravel underlies the hard-packed sand and gravel to an approximate depth of 93 feet. Sand was encountered between 93 and 96 feet bgs. Low permeability layers consisting of interbedded clayey silt and sand underlie the sand to an approximate depth of 100 feet. Silty clay, another low permeability layer, was encountered beneath the clayey silt and sand to a depth of approximately 101 feet. Results of the seismic reflection survey confirm the depth of the lower permeability layers near the Pier 1 store and indicate the presence of another lower permeability layer at an approximate depth of 150 feet bgs. The seismic reflection survey

indicated that the depth to a low permeability layer northwest of the Pier 1 store near the Olive Garden Restaurant (Plate 2) deepens to approximately 160 feet bgs.

5.1.2 Groundwater Conditions

Water levels measured in wells at the site reflect the regional trends. In general, depth to water ranges from approximately 10 to 15 feet bgs during the irrigation season (April to October), and from approximately 15 to 20 feet bgs during the nonirrigation season (November to March). In the northernmost wells on the site (GZA wells 1, 2, and 3), water levels are approximately 10 to 15 feet deeper due to the higher ground surface elevation. Groundwater flow direction and gradients calculated during the September 1991 groundwater survey (HLA, 1991a) indicated that groundwater flows toward the north-northwest at an approximate gradient of 0.001 to 0.003 ft/ft; this flow direction is consistent with regional trends.

5.2 Nature of VOCs

Six halogenated and aromatic VOCs have been detected in soil and groundwater samples collected since site characterization activities began in 1989. Other compounds detected in the soil gas surveys conducted in 1992 and 1993 have not been included in this discussion because soil gas is intended to provide only a qualitative screening of the soil and groundwater chemistry, and these compounds were not detected in soil or groundwater. The compounds detected include: PCE; TCE; 1,1,1-TCA; 1,2-DCE; 1,1-DCE; and toluene. TCE, 1,2-DCE, and 1,1-DCE are transformation byproducts (degradation products) of PCE.

Of the six chemicals detected in soil and groundwater samples collected from the site, PCE has been chosen as the primary chemical of concern based on the site history, frequency of detection, areal distribution, and concentration.

5.3 Occurrence of VOCs in Soil

Analytical results from the 1991 soil sampling indicated that PCE was detected in four soil borings at concentrations ranging from 0.21 to 26,000 mg/kg. The highest concentration of 26,000 mg/kg was detected in Boring B-1 at a depth of 5.5 feet; boring B-1 was installed immediately adjacent to the former PCE AST (Plate 3). In 1994, Boring B9405 was installed in approximately the same vicinity as Boring B-1 (Plate 5). The sample collected from Boring B9405 at a depth of 5.5 feet contained PCE at a concentration of 0.088 mg/kg. This dramatic reduction in PCE concentrations indicates that the existing SVE system has been extremely effective at reducing subsurface PCE concentrations. Additionally, of the four borings installed in 1994 in the vicinity of the former PCE AST, only Boring B9405 contained detectable concentrations of PCE; therefore, site vadose zone soil is considered to be effectively remediated.

5.4 Occurrence of VOCs in Groundwater

Sixteen wells have been installed by VW&R and others in the shallow aquifer at the site. The areal distribution of the wells, when combined with other available data (e.g., soil gas data), is sufficient to delineate the extent of VOCs in groundwater at the site. To illustrate the areal extent of PCE-impacted groundwater, isoconcentration contours are presented on Plate 2. In preparing the isoconcentrations contours, data from wells installed in the deeper portions of the shallow aquifer (VW&R Wells MW-1 and MW-2) have been excluded. Additionally, soil gas data has been used qualitatively in conjunction with the quantitative evaluation of the groundwater data to derive the isoconcentration contours. The use of soil gas data to augment the monitoring well data is justified because the geologic conditions are amenable to the degassing of VOCs from groundwater into an equilibrium state.

The highest concentration of PCE is present in the upper screened interval of Well EW-1, immediately downgradient of the former PCE AST. PCE concentrations decrease with distance

from this area, with significantly lower concentrations (approximately 1 order of magnitude) detected in State Well MW-1 located approximately 350 feet downgradient of Well EW-1, and a decrease of approximately 2 orders of magnitude in monitoring wells along the northwestern boundary of the site.

The vertical distribution of PCE was evaluated primarily using data generated during the Pilot Boring Program and installation of the extraction well (EW-1). These data and analytical data from previous groundwater sampling activities at the Mall indicate that the PCE is primarily limited to the shallow portion of the aquifer. PCE was detected in Well EW-1 at a concentration of 24 $\mu\text{g/l}$ at a depth of 95 feet. Lithologic data obtained from the boring for Well EW-1 and the geophysical survey indicate the presence of a low permeability layer (i.e., silty clay) at an approximate depth of 100 feet in that area. Based on the low concentrations of PCE detected at 95 feet and the presence of a low permeability layer at an approximate depth of 100 feet, it appears that PCE is limited to the upper 100 feet of the aquifer in the vicinity of the former PCE AST.

Downgradient of the former PCE AST, chemical data obtained from VW&R Wells MW-1 and MW-2 indicate that PCE is limited to the upper 75 feet below ground surface. Based on the chemical data, site stratigraphy, and the areal extent of PCE, it appears that vertical (downward) groundwater flow within the aquifer is not significant.

Based on the areal and vertical distribution of PCE in groundwater at the site (i.e., PCE extends downgradient parallel to the groundwater flow direction in a narrow plume), it appears that the PCE is being transported primarily via advective flow (i.e., at a retarded rate somewhat less than the groundwater flow velocity) and, to a lesser extent, via hydrodynamic dispersion (i.e., some dilution both longitudinally, transversely, and to a lesser extent, vertically, from uncontaminated groundwater as the PCE moves through the aquifer).

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6.0 RISK ASSESSMENT SUMMARY

On May 31, 1994, HLA submitted the draft risk assessment for the site (Mall RA) to the Department on behalf of VW&R (HLA, 1994b). The Department provided comments in a letter dated July 5, 1994 (Department, 1994a). The scope of work for the Mall RA was presented in the Boise Mall Order as *Exhibit #3, Work Plan, Boise Towne Square Mall Supplemental Investigation and Final Remediation, Boise, Idaho*, dated September 8, 1992 (HLA, 1992b) and detailed in the Mall Risk Assessment Work Plan (HLA, 1993b). The Mall RA Work Plan was prepared by HLA and approved by the Department.

The objectives of the RA were to:

(1) characterize the current and potential threats to human health and the environment posed by the presence of Perc (PCE) and other compounds detected in soil and groundwater at the Site and immediately downgradient of the Site, (2) provide a basis for risk management decisions, and (3) identify medium- and chemical-specific cleanup goals (CLs) to be used in the RAP. The RA used methods consistent with EPA guidance for performing risk assessments.

Based on the results of investigations conducted by HLA, VW&R, and others, PCE, TCE, and 1,2-DCE were identified as chemicals of potential concern (COPCs; HLA, 1993b). Investigations performed in 1994 in the AST area indicate VOCs have been removed from and are no longer present in vadose zone soil at the site at elevated concentrations; PCE was detected in 2 of 10 samples with a maximum concentration of 0.11 milligrams per kilogram (mg/kg). Results of groundwater monitoring indicate the continued presence of the COPCs in groundwater. Additional impacted groundwater extends downgradient (northwest) of the site into the PSA. The PSA is being evaluated in a RA under a separate consent order between VW&R and the Department (HLA, 1993i).

Ecological receptors are not expected to be exposed to or affected by COPCs at the site because (1) ecologically sensitive habitats are not

present at the site, and (2) the COPCs are not expected to be present in media where ecological receptors could come into contact with them (i.e., onsite stormwater runoff; other surface water bodies such as wetlands or sloughs are not present onsite).

In the Mall RA Work Plan, a preliminary conceptual model identifying the possible complete human exposure pathways at the site was developed. The identified pathways were ingestion of and direct contact with soil, and inhalation of vapors from soil and/or groundwater that might diffuse into indoor and outdoor air. As stated previously, 1994 site investigation results indicate that site-related chemicals in vadose zone soil are absent; therefore, the only complete exposure pathways to COPCs considered in the RA were: inhalation of vapors released from COPCs in groundwater to (1) indoor air, and (2) outdoor air. As stated in the RA Work Plan, direct exposures to the COPCs in groundwater at the site are unlikely because the groundwater is not used for onsite domestic, irrigation, commercial or industrial purposes, and onsite construction and excavation activities are not expected to contact groundwater.

Based on current site conditions, current direct exposures to site-related chemicals are not expected; however, possible human inhalation exposures using hypothetical exposure scenarios were quantified in the RA to provide risk managers with information to protect human health and environmental resources (such as groundwater). Hypothetical average and reasonable maximum exposure (RME) scenarios were used to evaluate health risks from possible indoor and outdoor exposures to the COPCs vapors. Up to four hypothetical receptors were used to develop these scenarios, as appropriate; these are child and adult shoppers, an adult worker such as a cashier, and a gardener in the landscaped areas of the site.

Possible exposures associated with the COPCs are dependent upon source groundwater concentrations. Possible exposures to receptors

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were quantified using four groundwater source concentrations: 5, 500, and 1,000 $\mu\text{g/l}$ of PCE (Plate 2), and the RME concentrations for 1,2-DCE, PCE, and TCE (i.e., the lesser of the maximum and 95 percent upper confidence limit [UCL] of the arithmetic mean concentrations). Chemical concentrations in air were estimated using mathematical chemical vapor release, transport, and dispersion models. The air concentration estimates were used in conjunction with average and RME human intake values used to describe average and RME exposure scenarios, to estimate a range of possible inhalation exposures to 1,2-DCE, PCE, and TCE.

EPA-developed toxicity values are used to separately quantify noncancer health effects and cancer risks associated with the exposure estimates (EPA, 1989a). Even though EPA-developed reference doses or reference concentrations were not available from EPA, daily intake values (doses) for noncancer effects were calculated in the RA to estimate noncancer effects of the COPCs (EPA, 1993, 1994). Slope factors were available to estimate cancer risks.

The estimated cancer risks range from 3×10^{-12} to 3×10^{-7} for the average scenarios and 5×10^{-11} to 1×10^{-6} for the RME scenarios. The estimated cancer risks are below the National Contingency Plan (NCP) remediation target risk range of 1×10^{-4} to 1×10^{-6} (one-in-ten-thousand to one-in-one-million probability that an exposed individual may develop cancer over a lifetime of continuous exposure. Since the estimated cancer risks for the only complete pathways (i.e., inhalation of indoor and outdoor air) identified at the site were less than the remediation target risk range, development of CLs were deemed unnecessary to protect potential onsite receptors from adverse inhalation exposures.

In summary, the conclusions of the RA are that:

- The only complete exposure pathways identified were inhalation of vapors from groundwater in both indoor and outdoor air; however, health risks quantified in the RA were found to be less than target risk criteria

- No complete pathways for ingestion of and dermal contact with groundwater are present at the site
- No complete direct soil pathways are present at the site
- No complete surface water pathways are present at the site
- No ecological receptors are present at the site
- The RA was conservative; therefore exposure and risks were likely overestimated
- CLs were not calculated in the RA because no need for remediation was identified to protect onsite receptors from inhalation of vapors from groundwater (this was the only complete exposure pathway identified)
- Remediation of the COPCs in groundwater is not necessary at this site to protect human health or the environment with respect to the complete pathways identified at this site. Nonetheless, groundwater remediation is recommended to prevent migration of VOCs to downgradient locations where other types of exposure may occur to human and/or ecological receptors. As stated in the Mall RA Work Plan, MCLs are the proposed CLs for the groundwater at this site. Establishment of MCLs as proposed cleanup levels for groundwater at the Mall is overly protective of human health since the Mall risk assessment concluded that the health risks for the two identified complete pathways (i.e., inhalation of indoor and outdoor air) are less than the target risk criteria defined in the National Contingency Plan.

Implementation of groundwater remedial activities at the Mall will, however, promote accelerated remediation of groundwater, particularly in downgradient areas, (i.e., the Preliminary Study Area [PSA] where the potential for complete pathways other than those identified at the Mall is greater. A risk assessment for the PSA is currently being prepared which will identify any completed

pathways and receptors in the PSA, and evaluate potential health risks to identified receptors due to potential exposures to impacted media.

After completion of PSA risk assessment, re-evaluation of the proposed clean up levels may

be necessary to identify if concentrations of the specified chemicals of concern in groundwater other than the MCLs are required to protect human health. If applicable, this health-based cleanup level would be proposed for the Mall pending approval of the Department.

7.0 SITE INVESTIGATION SUMMARY

This section summarizes the principal findings of the site investigation in terms of site geology and hydrogeology, soil quality, groundwater quality, potential migration pathways, and potential risk to human health and the environment.

7.1 Site Geology and Hydrogeology

Based on the integration of all the data available from project-specific borings and a review of regional geology, the geology and hydrogeology at the site may be summarized as follows:

- The stratigraphy at the site consists of approximately 3 to 5 feet of silty clay fill underlain by gravel and sand mixtures, silt, or clayey sand to an approximate depth of 11 feet. Sand and gravel underlie the finer materials to an approximate depth of 70 feet. The sand and gravel are hard-packed between depths of approximately 14 and 48 feet. Silty sand with gravel underlies the hard-packed sand and gravel to an approximate depth of 93 feet. Sand was encountered between 93 and 96 feet bgs. Low permeability layers consisting of interbedded clayey silt and sand underlie the sand in the vicinity of the Pier 1 Imports building to an approximate depth of 100 feet. Silty clay was encountered beneath the clayey silt and sand to a depth of approximately 101 feet, the maximum depth the borehole for Well EW-1 was drilled.
- Results of the seismic reflection survey confirm the depth of the lower permeability layers near the Pier 1 store and indicate the presence of another lower permeability layer at an approximate depth of 150 feet bgs. The seismic reflection survey indicated that the depth to a low permeability layer northwest of the Pier 1 store near the Olive Garden Restaurant deepens to approximately 160 feet bgs.
- The unconsolidated silt, sands, and gravels that comprise the shallow aquifer in the site

vicinity are of Pleistocene Age and were deposited and reworked by the Boise River.

- The shallow aquifer beneath the site is unconfined. Groundwater levels fluctuate during the irrigation season. In general, depth to water ranges from approximately 10 to 15 feet bgs during the annual irrigation season, and from approximately 15 to 20 feet bgs during the annual nonirrigation season.
- Groundwater flows toward the north-northwest at a gradient ranging from 0.001 to 0.003 ft/ft.

7.2 Soil Quality

Soil quality assessments conducted during and prior to the Site Investigation indicate the following:

- The most prevalent VOC detected in soil at the site was PCE. The highest detected concentration of PCE was present immediately adjacent to the former PCE AST location near the Pier 1 Imports store.
- Data collected in 1994 indicates that the existing SVE system has reduced the PCE concentrations in vadose zone soil at the site by four orders of magnitude to less than 0.5 mg/kg in the immediate vicinity of the former PCE AST, and to nondetectable concentrations in other areas of the site.

Vadose zone soil, therefore, is no longer considered to be a source of PCE at the site and will not require any additional remediation. The SVE system will continue to operate, however, and will be used in the groundwater remediation system proposed for the site (Section 11.0).

7.3 Groundwater Quality

The following summary of groundwater quality conditions is based on monitoring data collected during and prior to the SI.

- The most prevalent VOCs in groundwater are PCE, TCE, and 1,2-DCE. Of these, PCE is considered to be the primary chemical of concern based on the site history, frequency of detection, areal and vertical extent, and concentration.
- The concentrations of PCE in shallow groundwater at the site are highest immediately downgradient of the former PCE AST location and decrease toward the northwest (downgradient).
- The vertical distribution of PCE appears to be concentrated in the upper 40 feet of the shallow aquifer and limited to the upper 100 feet of the shallow aquifer in the immediate vicinity of the former PCE AST, and to the upper 75 feet of the shallow aquifer downgradient of the former PCE AST.
- Based on the areal and vertical distribution of PCE in groundwater at the site, it appears that PCE is being transported primarily via advective flow and, to a lesser extent, via hydrodynamic dispersion.
- The only complete exposure pathways identified for the site were inhalation of vapors from groundwater in both indoor and outdoor air; however, health risks quantified in the RA were found to be less than target risk criteria.
- No complete pathways for ingestion of and dermal contact with soil, groundwater, or surface water are present at the site.
- No ecological receptors are present at the site.
- CLs were not calculated because no need for remediation was identified to protect onsite receptors from inhalation of vapors from groundwater.

Remediation of the COPCs in groundwater is not necessary to protect human health or the environment with respect to the complete pathways identified for the site. Nonetheless, groundwater remediation is recommended to prevent migration of VOCs to downgradient locations where other types of exposure may occur to human and/or ecological receptors.

7.4 Risk Assessment Summary

The results of the Risk Assessment indicated:

- Three COPCs were identified: PCE, TCE, and 1,2-DCE.

8.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The remaining sections of this document present the Remedial Action Plan for the site. This Remedial Action Plan contains the following elements as specified in the Boise Mall Consent Order.

- a. Proposed alternative methods of cleanup, removal or treatment of contaminated soil and groundwater, including evaluation of effectiveness of current on- and offsite remediation as the same directly affect onsite conditions, selection of preferred alternative(s) and supporting analyses. Evaluation of methods of cleanup shall take into account:
 - (i) overall protection of human health and the environment;
 - (ii) compliance with applicable or relevant and appropriate requirements;
 - (iii) long-term effectiveness and permanence;
 - (iv) reduction of toxicity, mobility, or volume;
 - (v) short-term effectiveness;
 - (vi) implementability;
 - (vii) cost;
 - (viii) community acceptance; and
 - (ix) State acceptance.
- b. The proposed equipment to be used for cleanup, removal or treatment of contaminated soil and groundwater and the proposed method of decontaminating such equipment;
- c. A description of the proposed methods for transporting and disposing of the contaminated material, if necessary;
- d. All applicable or relevant and appropriate standards for the protection of human health and the environment (e.g., National Ambient Air Quality Standards, State or federal approved water quality standards);
- e. A description of the approach and procedures for any proposed soil and groundwater

sampling. Sampling may be conducted to assist in the design of the proposed methods of cleanup, removal or treatment of contaminated soil and groundwater;

- f. Proposed CLs for Perc Compounds and, if required pursuant to this Consent Order, Aromatic Compounds, in contaminated soils and groundwater;
- g. General project schedule (identifying dates for completion of the project and major milestones); and
- h. A conceptual description of potential future changes in remedial measures.

The remedial action process begins with the identification and initial screening of remedial alternatives considered potentially applicable to the site-specific conditions. The remedial objectives are based on potentially applicable or relevant and appropriate requirements (ARARs) and the protection of public health and the environment. The initial screening process eliminates those remedial alternatives considered inappropriate due to site-specific conditions and/or environmental considerations. This section addresses the development of the site-specific remedial action objectives and the identification and initial screening of remedial alternatives.

8.1 Remedial Action Objectives

Remedial action objectives are based on protecting human health and the environment and are site- and medium-specific. For the purposes of this Remedial Action Plan, the environmental medium considered for remediation is groundwater. As described in the Mall Risk Assessment, the groundwater beneath the site is not considered a drinking water source at the site and does not pose a risk to human health or the environment with regard to complete exposure pathways identified at the site (e.g., inhalation of vapors via indoor and outdoor air). However, all groundwaters of the State are

considered a potable supply unless they are specifically designated otherwise. For this reason, it is anticipated that groundwater at the site will require some remediation. The vadose zone soil beneath the area of the former AST has been remediated as described in Section 5.3 and is not further considered in this RAP.

8.1.1 Chemicals of Concern

Chemicals of potential concern (COPCs) were selected during the Mall Risk Assessment by evaluating the percent contribution of each chemical to the overall potential cancer risk or hazard index and by the frequency of an individual chemical's detection. The final list of chemicals of potential concern for the determination of CLs is:

- tetrachloroethene (PCE)
- trichloroethene (TCE)
- 1,2-dichloroethene (1,2-DCE)

8.1.2 Applicable or Relevant and Appropriate Requirements

Remedial action alternatives are intended to protect human health and the environment. The level of protection is usually based on potential ARARs. The EPA (EPA, 1988) defines potential ARARs as follows:

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal and state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.
- Relevant and appropriate requirements are those standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a

CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

Three categories of potential ARARs are identified by the EPA (EPA, 1988a):

- Chemical-specific requirements set health or risk-based concentration limits or ranges for particular chemicals in the ambient environment.
- Performance, design, or other action-specific requirements governing specific activities with respect to the remedial action taken.
- Location-specific requirements set restrictions on activities, depending on the characteristics of a site or its immediate environment.

The identification of potential ARARs is an iterative process which involves first identifying the chemicals of concern and the media in which they are found (i.e., water, soil, or air). The actual or potential uses of the affected media are then determined and potential ARARs are identified for each chemical in each medium based on these uses. Remedial alternatives considered capable of attaining the required level of cleanup are identified and potential chemical-specific and location-specific ARARs associated with each remedial alternative, coupled with the results of the risk assessment, are identified to develop cleanup goals.

8.1.2.1 Potential ARARs for Groundwater

The aquifer is not currently used as a drinking water source at the site and is not expected to be used as a drinking water source at the site in the foreseeable future. Nonetheless, all aquifers of the State are considered a potable supply unless they are designated otherwise (i.e., geothermal waters). As stated in the Mall RA, MCLs are the proposed CLs for the groundwater at the site as described in Section 6.0. A separate risk assessment is being conducted for the area downgradient of the site; the RA will further evaluate risk-based CLs for the site, which may be higher than drinking water ARARs.

EPA (March 8, 1990) may consider maximum contaminant level goals (MCLGs) established under the Safe Drinking Water Act to be potential ARARs if the groundwater is a potential drinking water source and if the MCLG is greater than zero. If the MCLG for a particular contaminant is zero, then the maximum contaminant level (MCL) set under the Safe Drinking Water Act is considered to be a potential ARAR. The federal MCLs and MCLGs for PCE, TCE, and cis-1,2-DCE are 5/0, 5/0, and 70/70 $\mu\text{g/l}$, respectively.

8.1.2.2 Potential Action-Specific ARARs

Action-specific ARARs are triggered by the type of remedial action under consideration. For example, groundwater extraction and treatment system may be proposed for use at the site. Treated groundwater could be discharged into the Ada County Highway District storm drains which discharge to the Nampa-Meridian Irrigation System's Finch Drain, previously known as the South Slough. The discharge would then have to meet requirements of a NPDES permit issued by the EPA and State.

8.1.2.3 Potential Location-Specific ARARs

The location and certain physical characteristics of a site may influence the type and location of responses considered. Potential location-specific ARARs pertain to facilities located within fault zones, archaeological areas, coastal zones, and critical habitats for endangered species. The site is not subject to any of the location requirements. The Fish and Wildlife Coordination Act pertaining to streams and rivers may be a potential ARAR with respect to discharge of treated groundwater into the Finch Drain.

8.1.2.4 Miscellaneous Potential ARARs

State of Idaho air and hazardous waste provisions may be relevant and appropriate requirements for the site. Federal and state occupational health and safety standards may also be applicable. Federal and Idaho OSHA general industry and construction standards are set under 29 CFR

Section 1910 et seq., 29 CFR Section 1926 et seq., and 8 CFR Part 1, Chapter 4.

8.1.3 Remediation Goals

CLs are developed to yield chemical concentrations considered protective of public health. Although groundwater beneath the site is not currently considered to be a risk to human health or the environment at the site, it may be used as a drinking water source downgradient of the site. Therefore, non-zero MCLGs or federal MCLs were selected as the proposed CLs for groundwater as described in Section 6.0. However, it may not be technically feasible to achieve these levels based on the physical and chemical characteristics of the saturated soils in the shallow aquifer and existing remediation technology.

8.2 General Response Actions

In accordance with the EPA's guidelines for conducting feasibility studies under CERCLA (EPA, 1988b), a range of general response actions is considered to meet the remedial action objectives for groundwater impacted by VOCs. These general response actions are:

- No action
- Containment
- In situ treatment
- Removal.

The no action response is considered in accordance with the NCP (EPA, 1990) and is intended to provide a basis for comparison to other response actions. Containment involves preventing or minimizing migration and reducing the potential for exposing potential receptors to the hazardous materials. In situ treatment is a response whereby the material is treated in place to reduce its toxicity and/or mobility and, thereby, reduce the potential excess risk to human health and the environment. The removal response involves physically removing the hazardous material from its environment to render the material nonhazardous and/or immobile, to destroy of the material, or to

transfer the material to a media or location at which the potential risk to human health and the environment is within acceptable limits.

Based on the remedial action objectives and the proposed CLs as described in Section 6.0, potentially appropriate remedial technologies within each general response category were identified. Brief descriptions of the principal features of the various remedial technologies in each category are presented in the following sections. The applicability of each technology to site-specific conditions has been evaluated in terms of technical implementability. Only those technologies judged implementable have been retained for further consideration.

8.3 Groundwater Remediation Technologies

The groundwater remediation technologies selected for initial screening under each general response action are as follows:

<u>RESPONSE ACTION</u>	<u>REMEDIAL TECHNOLOGY</u>
No action	<ul style="list-style-type: none"> • None; however, groundwater monitoring may be required
Containment	<ul style="list-style-type: none"> • Physical containment • Hydraulic containment
In Situ Remediation	<ul style="list-style-type: none"> • Bioremediation • Chemical treatment • Vapor extraction • Air sparging and vapor extraction
Removal	<ul style="list-style-type: none"> • Extraction and treatment by air stripping • Extraction and treatment by carbonaceous adsorption (resin/GAC) • Extraction and treatment by air stripping and carbonaceous adsorption (resin/GAC) • Extraction and treatment by chemical/ultraviolet oxidation • Extraction and treatment by bio-oxidation.

These technologies and their potential applicability/implementability with respect to the site are discussed below. A summary of the initial screening process is presented in Table 6.

8.3.1 No Action Response

Under the no action response, no further engineering actions would be made to remediate groundwater. Groundwater monitoring, however, would continue. Contaminant reduction could occur under natural processes, including biodegradation, dilution, and volatilization. However, under the no action scenario, the downgradient migration of VOCs from the site would probably continue. Although the risks associated with groundwater conditions (Section 6.0) at the site are within the acceptable range, groundwater is a drinking water source downgradient of the site. Therefore, if remediation were not undertaken downgradient to remediate water which is being used as drinking water, or other considerations related to the offsite migration of the groundwater, the no action response would not be appropriate for the site. However, for completeness and in accordance with EPA guidelines, the no action response is retained for more detailed evaluation in the subsequent stages of the remediation evaluation process.

8.3.2 Containment Technologies

Containment technologies are those which effect partial or complete isolation of a waste material from the surrounding environment. Aside from attenuation due to natural phenomena, such as biodegradation, the chemical concentrations in groundwater would remain essentially unchanged. Containment technologies should, therefore, be designed for long-term operation and usually require long-term monitoring.

8.3.2.1 Physical Containment Technologies

Physical containment technologies considered for preliminary screening include slurry cutoff walls, grout curtains, and sheet pile walls. To be effective, such barriers should encircle the impacted area, be emplaced into a lower permeability horizontal stratum at depth, and be

implemented in conjunction with some form of hydraulic control (normally extraction and treatment of groundwater from inside the containment area).

Physical barriers would be difficult to implement due to surface and subsurface obstructions. Additionally, in order to contain the impacted aquifer effectively, the physical barriers would have to be emplaced into the low permeability strata at an approximate depth of 100 feet below grade. The physical barriers would, therefore, have to be relatively deep to be effective and would be technically difficult to install. Hydraulic control measures would typically involve groundwater extraction from within or hydraulically upgradient of the contained area.

On the basis of the above constraints, physical barriers capable of effectively containing groundwater containing VOCs would be technically difficult to implement and, accordingly, have not been retained for further consideration.

8.3.2.2 Hydraulic Containment

Hydraulic containment of groundwater involves the creation of extraction barriers via wells and/or trenches. Strategically placed extraction wells can achieve containment beneath surface structures and other areas.

Hydraulic containment by groundwater extraction has been demonstrated to be implementable and effective in remediating groundwater at the site. As a stand-alone remedial technology, however, hydraulic containment may not be practical due to the generation of large volumes of chemical-containing groundwater which must be treated prior to discharge. Accordingly, hydraulic containment is only feasible in conjunction with treatment and a cost effective and practical discharge or reuse alternative. This combination of technologies is discussed further in Section 8.3.4. Based on the depth of contaminants in the shallow aquifer and depth limitations of trench construction technologies, extraction trenches are not considered further for those technologies involving groundwater extraction. Groundwater extraction via extraction

wells is considered potentially applicable to site-specific conditions and has been retained for further consideration.

8.3.3 In Situ Remediation Technologies

In situ remediation technologies typically involve the use of chemical or biological agents or air to degrade, remove, or immobilize contaminants in groundwater. The in situ remediation technologies considered for preliminary screening are vapor extraction, air sparging and vapor extraction, chemical treatment, and bioremediation.

8.3.3.1 In Situ Soil Vapor Extraction

In situ soil vapor extraction (SVE) is a process whereby VOCs are volatilized and removed from the soil and, to a lesser extent, groundwater matrices using an induced air current. The air current is typically induced by applying a negative pressure (vacuum) to one or more vapor extraction wells and/or trenches. The SVE process is analogous to the extraction of groundwater from wells in that air in the soil pore space is drawn toward the extraction point and removed. SVE systems can often be designed to minimize site disturbance while remediating organic chemical-containing soils and groundwater beneath existing surface obstructions. SVE systems almost invariably involve some form of treatment for the extracted vapors prior to their release to the atmosphere.

SVE is most appropriate in granular soils, which more readily allow the passage of air. SVE has, however, been applied successfully to lower permeability soils. The duration of the remedial effort is typically longer for fine-grained soils, and higher pressure gradients may be required to induce air flow. In addition to the air permeability of the soil matrix, the effectiveness of SVE is dependent on the moisture content of the soil and the characteristics and distribution of the VOCs to be remediated. In general, soils with high moisture content are less conducive to vapor extraction. The chemical characteristics that most influence "strippability" are the solubility of the compound(s) in water and volatility. Generally, those compounds that are

highly soluble in water and those that are less volatile are more difficult to remove. A SVE system has been operating at the site since 1992. As outlined in Section 2.3.1, this SVE system has operated very effectively.

The VOCs present in groundwater at the site, such as PCE, can be readily volatilized. On the basis of the above and the proven effectiveness of the existing onsite SVE system, SVE is considered applicable to the site-specific conditions and has been retained for further consideration.

8.3.3.2 Air Sparging/Vapor Extraction

Air sparging is a process whereby VOCs are removed from the subsurface saturated zone by injecting air into the impacted aquifer. The VOCs then transfer from the impacted soil and/or groundwater into vadose zone vapors in the form of sparged air bubbles, where they are removed using SVE (described above). Air sparging increases the rate of VOC transport from groundwater to the soil vapor phase and is generally quicker and more effective at remediating groundwater than SVE alone.

Air sparging combined with SVE is most appropriate in unconfined aquifers in sandy soils where the depth to groundwater is greater than 5 feet and contaminants of concern are highly volatile dissolved and/or light nonaqueous phase liquids. On the basis of the above, air sparging/SVE is considered potentially applicable to the site-specific conditions and have been retained for further consideration.

8.3.3.3 Chemical Treatment

In situ treatment involves introducing chemicals (surfactants) that will either mobilize the VOCs present in soil and/or groundwater so they may be extracted or degrade the compounds to less hazardous byproducts. The primary limitations of this technology are the means by which the treatment agents are delivered to and maintained in the groundwater and the nature of the byproducts or transition products. Conceptual approaches to delivering the treatment agent include trenches, infiltration galleries, and

injection wells. Trenches would be appropriate primarily for shallow groundwater applications in which trenches could be excavated perpendicular to the direction of flow and filled with a permeable material via which the chemical agents could be delivered. Infiltration galleries would function in a similar manner; however, the treatment agent would have to percolate through some interval of unsaturated soil prior to reaching the water table. Injection through wells is perhaps the most flexible and least disruptive method of introducing chemical treatment agents to groundwater, particularly to deeper areas. However, the introduction of chemical treatment agents to groundwater may generate unanticipated transition products and/or byproducts, and may increase the areal or vertical extent or concentration of the contaminant plume.

Based on the above, significant technical and administrative difficulties are anticipated with the implementation of in situ chemical treatment to remediate groundwater. Accordingly, this technology has been eliminated from further consideration.

8.3.3.4 Bioremediation

Bioremediation of groundwater involves adding suitable microorganisms and/or enhancing the activity of indigenous microorganisms to break down and detoxify the VOCs present in groundwater. Although a wide range of microorganisms is available for aerobic biodegradation, none have been consistently effective in the treatment of water containing chlorinated organic compounds such as those detected at the site. As a result, aerobic bioremediation is unlikely to be technically applicable to groundwater conditions at the site and in situ bioremediation has not been considered further.

8.3.4 Groundwater Extraction/Treatment Technologies

Removal or extraction technologies are those which physically remove organic chemical-containing groundwater from the aquifer. The extracted groundwater is typically

treated prior to discharge. As the extraction process is common to all of the removal technologies, the following evaluations focus primarily on the various treatment methods available. The extraction/treatment technologies considered during the preliminary screening process are as follows:

- Extraction and treatment by air stripping
- Extraction and treatment by carbonaceous adsorption (e.g., GAC or resin)
- Extraction and treatment by air stripping/carbonaceous adsorption
- Extraction and treatment by chemical/ultraviolet oxidation
- Extraction and treatment by bio-oxidation

These technologies are described in the following sections.

8.3.4.1 Extraction and Treatment by Air Stripping

Air stripping is a well-developed, proven, and cost-effective technology for the removal of VOCs from groundwater. The most common configuration involves the delivery of VOC-containing water to the top of a packed tower; the water trickles down through the packing material and the VOCs are removed or "stripped" by a countercurrent of air flowing up through the tower. The "stripped" water is then discharged. The equipment required for a packed tower air stripper is relatively simple and modular designs are available. The space required is small, and startups and shutdowns can be accomplished quickly. Following startup, the air stripper can be expected to achieve its anticipated level of performance quickly. Air stripping technology has developed to the extent that pilot testing is normally not required if, as is the case at the site, the type and concentrations of the VOCs are known.

Packed-tower air stripping, therefore, is a feasible groundwater treatment technology for the site.

Similar stripping processes, such as steam stripping or vacuum stripping, are more complex and difficult to implement and maintain. These technologies have, therefore, not been included in the initial screening of remedial technologies. Another variation, spray aeration, may be feasible but has not been evaluated as an individual process option. Pursuant to the Rules and Regulations for the Control of Air Pollution in Idaho Section 01.1012, off-gas treatment may be required for any new air stripping unit installed at the site.

8.3.4.2 Extraction and Treatment by Carbonaceous Adsorption

Carbonaceous adsorption using either granular activated carbon (GAC) or resins is a well-developed and proven technology for removing VOCs from extracted groundwater. The most common system configuration involves passing the water through multiple carbonaceous adsorbent vessels in series. The primary vessel is typically designed to remove most, if not all, of the contaminants to the desired levels. The secondary vessel is typically the same size (i.e., contains the same volume/mass of GAC) as the primary vessel and reduces residual contaminants to the design effluent standards. The secondary vessel is often referred to as the polishing vessel. When the adsorption capacity is reached in the primary vessel, the spent adsorbent is either replaced with new carbonaceous adsorbent or regenerated in situ.

Carbonaceous adsorbent vessels are available in "off the shelf" modular configurations and can be installed and brought on line relatively easily. The periodic replacement of spent GAC or regeneration of the resin is the primary maintenance item. Carbonaceous adsorbent adsorption is most effective in the removal of higher molecular weight organic compounds with low water solubility. The chlorinated hydrocarbons present in groundwater beneath the site fall within this category. Accordingly, carbonaceous adsorption is considered potentially feasible for groundwater remediation at the site.

8.3.4.4 Extraction and Treatment by Air Stripping and Carbonaceous Adsorption

Air stripping followed by carbonaceous adsorption (GAC or resin) combines two well-developed and proven technologies. The primary advantage of a combination system is that air stripping removes the bulk of the VOCs at relatively low cost, thus reducing the VOC loading on the downstream GAC or resin system. The combination system, therefore, can accommodate the varying influent concentrations that may be associated with a multiple well extraction system. Accordingly, a combination of air stripping and GAC or resin adsorption is considered potentially applicable to the site-specific conditions. Pursuant to the Rules and Regulations for the Control of Air Pollution in Idaho Section 01.1012, off-gas treatment may be required for any new air stripping unit installed at the site.

8.3.4.5 Extraction and Treatment by Chemical/Ultraviolet Oxidation

Chemical oxidation of chlorinated hydrocarbons is a promising technology for treating groundwater containing low concentrations of VOCs. The principal use of oxidation systems to date, however, has been in treating semivolatile organic compounds such as pesticides and phenols. The oxidation process permanently destroys organic compounds by reducing them to carbon dioxide, water, and salts. The process reportedly leaves no contaminated residue. A number of oxidation systems are available. Several of those used for groundwater treatment have reportedly been effective in removing VOCs. These systems have used a combination of ozone and ultraviolet light. The water is first treated with ozone to break down the hydrocarbon double bonds. The ozone is applied in a reactor in the presence of an ultraviolet light source and an ultrasonic transducer which enhances the oxidation process. Ozone in water decomposes to oxygen, free radicals, and hydrogen peroxide. The ultraviolet light enhances the productions of radicals that are particularly reactive with carbon/carbon double bonds. The ultrasonics

transducer promotes microscopic turbulence that accelerates the dissolution of ozone in water.

Although this process may be effective at treating groundwater containing low concentrations of VOCs, the concentrations of VOCs at the site are high. Therefore, extraction/ultraviolet oxidation has not been retained for further consideration.

8.3.4.6 Extraction and Treatment by Bio-Oxidation

Bio-oxidation is a process whereby groundwater containing organic compounds is degraded to nontoxic byproducts by indigenous or cultured microorganisms. The microorganisms degrade the VOCs by three general metabolic processes: fermentation, anaerobic respiration, and aerobic respiration. Of these methods, aerobic respiration is perhaps the most common. In aerobic respiration, the VOCs are broken down by a series of enzyme-mediated reactions for which the microorganisms require oxygen. However, bio-oxidation has not been effective in remediating groundwater containing chlorinated organic compounds such as those present at the site. Accordingly, bio-oxidation has not been retained for further consideration.

8.4 Summary of Initial Technology Screening

The preliminary screening of the remedial technologies and process options for groundwater at the site is summarized in Table 6.

Groundwater remediation technologies retained for further evaluation include the following:

- No action
- Hydraulic containment
- Vapor extraction
- Air sparging and vapor extraction
- Extraction with air stripping
- Extraction with adsorption (GAC or resin)

- Extraction with treatment by air stripping and adsorption (GAC or resin).

These technologies are evaluated in more detail and further screened in the next section.

9.0 SECONDARY SCREENING OF REMEDIAL TECHNOLOGIES

This section discusses the secondary screening of the remedial technologies and process options retained for further consideration following the initial screening process discussed in Section 8.0.

9.1 Screening Criteria

The criteria used to screen the remedial technologies and process options retained for further consideration are effectiveness, implementability, and order-of-magnitude cost.

9.1.1 Effectiveness Criterion

Effectiveness is evaluated relative to other process options within the same technology type. The evaluation focuses on three criteria:

- Anticipated effectiveness in achieving the target cleanup levels considering the volume and/or areal and vertical extent of the medium to be remediated
- Potential impact on human health and the environment during implementation, including the health and safety of workers involved in remediation activities and persons at the site
- Reliability of the technology or process considering site-specific conditions and the remedial action objectives and/or the target cleanup levels.

9.1.2 Implementability Criterion

The implementability criterion pertains to the technical feasibility and institutional acceptance of the remedial technologies and/or process options retained for further consideration. As technical feasibility has been established during the initial screening, the implementability evaluation pertains primarily to institutional acceptance. The term "institutional acceptance" pertains to the acceptability of a remedial technology, technical approach, or process option to the Department.

Other issues considered during evaluation using the implementability criterion may include the availability of skilled, health and safety-trained contractors and/or specialized equipment, public acceptance, and permitting requirements.

9.1.3 Cost Criterion

The application of this criterion is limited to relative rather than absolute costs; costs are categorized as being low, moderate, or high. Both capital and operation/maintenance (O&M) costs are evaluated. The cost evaluation also considers the relationship between cost and environmental benefit. Those technologies or process options with considerably higher unit costs that do not provide significantly greater protection of human health or the environment are not appropriate for implementation.

9.2 Screening of Groundwater Remediation Technologies

The groundwater remedial technologies retained for further evaluation pursuant to the initial screening process are as follows:

- No action
- Hydraulic containment
- Vapor extraction
- Air sparging and vapor extraction
- Extraction and treatment by air stripping
- Extraction and treatment by adsorption (GAC or resin)
- Extraction and treatment by air stripping and adsorption

A more detailed evaluation of these technologies, based on the criteria described in Section 9.1, is presented in the following sections. The screening process is summarized in Table 7. Extraction/treatment is one of the principal

mechanisms by which hydraulic containment is achieved. Accordingly, a detailed discussion of hydraulic containment as a stand-alone technology is not presented herein. It has been assumed, however, that the placement of the extraction wells and the rate of extraction for the extraction/treatment technologies would be sufficient to achieve hydraulic containment.

9.2.1 No Action

Under the no action response, no further attempt would be made to remediate groundwater conditions at the site.

Effectiveness: The no action option would not achieve the CLs or the remedial objectives. As the no action option would not involve any subsurface disturbances, no adverse impacts on human health and/or the environment would be expected during its implementation.

Implementability: Technically, the no action option can be easily implemented. Administratively, the no action option would be difficult to implement and may not be accepted by the public.

Cost: The capital costs associated with no action would be low. O&M costs would be low, due principally to the anticipated requirement for long-term groundwater monitoring. The overall cost of the no action option is considered to be low.

Based on the above, the no action option does not appear to be applicable to the site-specific conditions. In accordance with the NCP and to serve as a "reference" for comparative purposes, however, the no action option is retained for further evaluation.

9.2.2 In Situ Vapor Extraction

Vapor extraction has proven to be an effective technology for removing VOCs from vadose zone soils and, to a lesser degree, groundwater at the site.

Effectiveness: SVE alone would likely not achieve remediation goals for groundwater. However, when used in conjunction with air

sparging (described below), SVE can be effective in reducing VOC concentrations in groundwater.

Implementability: An SVE system is currently operational at the site. Although soil has been remediated in the vicinity of the former PCE AST, the SVE system continues to operate and remove VOCs from groundwater. The addition of wells to the system would be relatively easy to implement and permitting is not expected to be difficult.

Cost: The capital costs associated with the installation of additional SVE wells or trenches and associated piping are expected to be moderate. The principal capital costs would be associated with well and piping installation. O&M costs are expected to be moderate.

On the basis of the above, continued operation of the existing SVE system appears to be a cost-effective technology that can aid in the reduction of VOCs in groundwater near the former AST. However, SVE alone will not be effective in achieving the site-wide remedial goals for groundwater. For this reason, SVE alone has not been retained for further evaluation. However, SVE can also be used in conjunction with air sparging (described below) to increase its effectiveness.

9.2.3 Air Sparging/SVE

Air sparging coupled with SVE involves injecting air into the affected aquifer and extracting air from the vadose zone. Air sparging promotes VOC transfer from the groundwater to the vadose zone.

Effectiveness: Based on case studies presented in the literature (EPA, 1992), the nature of the organic compounds present in groundwater at the site, site conditions, and other VW&R air sparging projects, air sparging coupled with SVE is expected to be effective in achieving the remedial goals for groundwater, as contaminants would be physically removed and prevented from migrating to potential offsite receptors.

Potential adverse risks to the public during implementation of this option would pertain and apply primarily to exposure to contaminated

groundwater during well installation. These risks would be limited to those directly involved in the construction and would be minimized by use of the appropriate personal protective equipment (PPE).

Implementability: Air sparging wells or an air sparging "curtain" could be installed relatively easily at the site. Piping to the existing SVE system is expected to be easily implementable. Permits required for implementation would include well permits from the DWR, and potential modification of the air permit for the existing SVE treatment unit from the Department.

Cost: The capital costs associated with the installation of additional wells and piping to the existing SVE treatment unit are expected to be moderate. O&M costs are also expected to be moderate.

On the basis of the above, air sparging coupled with SVE is considered potentially applicable as a means of remediating groundwater and has been retained for further consideration.

9.2.4 Extraction and Treatment by Air Stripping

Groundwater extraction and treatment by air stripping is widely used to remove VOCs from groundwater. Air stripping is a proven technology that is effective in reducing the concentrations of VOCs in groundwater.

Effectiveness: Extraction and treatment by air stripping could be effective in achieving the remedial objectives for groundwater, as contaminants would be physically removed and prevented from migrating to potential offsite receptors. The concentrations of VOCs in groundwater would be expected to decrease and the associated potential excess risk to public health would decrease correspondingly. However, air stripping results in the transfer of the contaminants from water to the air, secondary treatment would therefore be required to treat the air from the air stripper. The secondary treatment generally consists of a vapor phase activated carbon system. The carbon system is costly to maintain and complex to operate due to

the poor operating characterization of activated carbon systems in a humid air stream (such as the discharge from air stripping units).

Potential adverse effects on public health and the environment during the implementation of this option would pertain primarily to exposure to contaminated soil and groundwater during well installation and organic chemical vapors in the air stripper off-gas. The potential excess risks associated with exposure to soil and groundwater would be limited to workers involved in remediation and could be minimized by the appropriate PPE. Potential excess risk to public health and the environment associated with air stripper off-gas would be mitigated in accordance with the requirements of the Department. These factors would be expected to provide adequate protection from potential adverse effects.

Implementability: Additional extraction wells could be installed relatively easily at the site. Air stripping units are available commercially in a variety of diameters, heights, and capacities. The extraction and air stripping technology is technically implementable. Institutionally, the technology is widely accepted as an effective means of remediating groundwater contaminated by VOCs. Permits required for implementation would include well installation permits from DWR, permits to construct and operate an air stripper from the Department, and a NPDES discharge permit. Well installation and NPDES permits should be readily procurable once a discharge location is confirmed. Permits pertaining to the air stripper are procurable; however, more time and supporting data may be required.

Cost: The capital costs associated with the installation of an extraction/treatment system employing air stripping are expected to be moderate. O&M costs are also expected to be moderate.

On the basis of the above, extraction and treatment by air stripping is considered potentially applicable as a means of remediating groundwater and has been retained for further consideration.

9.2.5 Extraction and Treatment by Carbonaceous Adsorbent

The extraction and treatment of groundwater by carbonaceous adsorption (GAC or resin) is a widely accepted technology for groundwater remediation. An appropriate system for the site would consist of a series of carbonaceous adsorbent vessels.

Effectiveness: Extraction and treatment by carbonaceous adsorbent would be an effective means of achieving the remedial objectives for groundwater, as contaminants would be physically removed and prevented from migrating to potential offsite receptors.

Potential adverse effects on public health and the environment during the implementation of this option would pertain primarily to exposure to contaminated groundwater during well installation and to VOCs during the handling of spent carbon. The potential excess risks associated with these exposure pathways would be limited to workers involved in remediation activities and could be minimized using the appropriate PPE.

Extraction and carbonaceous adsorption are both proven and reliable processes with respect to the contaminants and hydrogeologic conditions at the site.

Implementability: Additional extraction wells could be installed relatively easily at the site. Carbonaceous adsorption units are available commercially in a variety of diameters, heights, and capacities. The extraction and adsorption technologies are technically implementable. Institutionally, the technologies are widely accepted as an effective means of remediating groundwater contaminated by VOCs. Permits required for implementation would include well installation permits from DWR and an NPDES discharge permit. These permits are considered readily procurable.

Cost: The capital costs associated with the installation of an extraction/treatment system employing carbonaceous adsorption are expected to be moderate. O&M costs for a GAC system are expected to be high, due primarily to the

necessity for the periodic replacement of spent carbon. O&M costs for a resin system are expected to be moderate. Accordingly, the overall cost of treatment by GAC is moderate to high and likely to be cost effective only if the average VOC concentrations in the influent are relatively low. GAC treatment of groundwater from wells at the site would, therefore, not be appropriate as a stand alone treatment technology but may be appropriate as a polishing phase. Resin would likely be more appropriate as a stand alone treatment technology.

Carbonaceous adsorption is a technically feasible and environmentally acceptable technology for groundwater remediation at the site. Accordingly, carbonaceous adsorption has been retained for further consideration as a treatment process option for groundwater.

9.2.6 Extraction and Treatment by Air Stripping and Resin or GAC

Treatment using both air stripping and carbonaceous adsorption combines two effective and well proven technologies for removing VOCs from groundwater. It has been assumed for the purposes of this evaluation that the air stripping and adsorption units would be installed in series. This configuration would have the advantage of removing most of the VOCs by air stripping with a reduced loading on the adsorption polishing units. The reduced loading would increase the service life of the adsorbent, resulting in a reduction in O&M costs.

Effectiveness: The environmental and public health effectiveness of this alternative is similar to that described in previous sections for air stripping and carbon adsorption.

Implementability: Air stripping and carbonaceous adsorption units are commercially available and could be combined and installed onsite relatively easily. The permitting and regulatory requirements for combined air stripping/carbonaceous adsorption are similar to those described for each of these technologies in the previous sections.

Cost: The capital and O&M costs of an air stripper/adsorption unit combination are expected to be moderate to high.

Although the combined air stripping/carbonaceous adsorption system would be effective, the degree of added protection to public health and the environment would be minimal compared to either air stripping or adsorption alone. Accordingly, the increased costs of the combined technologies may not be warranted and extraction and treatment by air stripping and carbon adsorption is not considered further.

9.3 Screening Summary

The more detailed evaluation of remedial technologies and process options retained after the initial screening considered effectiveness,

technical implementability/institutional acceptance, and relative cost. Table 7 summarizes the screening results.

Groundwater remediation technologies retained for possible inclusion in one or more of the site-wide remedial alternatives are as follows:

- No action
- Air sparging and vapor extraction
- Extraction and treatment by carbonaceous adsorbent (GAC or resin) or air stripping.

The development of remedial alternatives from these groundwater remediation technologies is addressed in Section 10.0.

10.0 DEVELOPMENT AND EVALUATION OF REMEDIAL ALTERNATIVES

The remedial technologies and process options listed in Section 9.3 have been identified as being technically feasible, potentially effective, institutionally acceptable, and potentially cost effective. This section pertains to the development and detailed evaluation of remedial alternatives that address the overall conditions at the site.

10.1 Development of Remedial Alternatives

For the purpose of developing remedial alternatives for detailed evaluation, both air sparging with vapor extraction and groundwater extraction and treatment by either carbonaceous adsorbent or air stripping are equally appropriate groundwater remediation techniques. Both may be utilized for groundwater remediation at the site. Accordingly, only two remedial alternatives have been assembled for detailed evaluation:

- | | |
|----------------|---|
| Alternative 1: | No action |
| Alternative 2: | Combination of air sparging with vapor extraction and/or groundwater extraction and treatment using either carbonaceous adsorbent or air stripping. |

The criteria by which these alternatives are evaluated are described below.

10.2 Detailed Analysis Criteria

The nine criteria used for the detailed analysis of the remedial alternatives are consistent with the statutory requirements for selection of remedial actions under CERCLA/SARA (EPA, 1988b) and the Boise Mall Order. Each alternative has been evaluated in terms of the nine criteria described below.

Long-Term Effectiveness and Permanence: This criterion evaluates the long-term effectiveness of the alternatives in maintaining protection of

human health and the environment after response objectives have been met. The factors considered in this evaluation include long-term reliability, future equipment maintenance requirements, and potential exposure to the residuals.

Reduction of Toxicity, Mobility, or Volume: This criterion evaluates the degree of expected reduction in toxicity, mobility, and volume of contaminants achieved by specific treatment alternatives.

Short-Term Effectiveness: This criterion evaluates the effectiveness of the alternatives in protecting human health and the environment during construction and implementation of remedial actions until response objectives have been met. The duration of the remedial effort is also considered.

Implementability: This criterion evaluates the technical and administrative feasibility of the alternatives, the availability of the remediation facilities, and the availability of specialized, health and safety-trained services. Anticipated levels of effort and difficulty are also considered.

Cost: This criterion evaluates the capital and O&M costs involved in implementing each remedial alternative. The O&M costs are based on the estimated duration of the remedial effort and include such items as groundwater monitoring, evaluations of effectiveness, and reporting. The cost estimates are intended for comparison purposes only and are considered accurate to within minus 30 to plus 50 percent.

Overall Protection of Human Health and the Environment: This criterion evaluates the degree of human health and environmental protection that can be achieved by a particular alternative as a whole.

Compliance with ARARs: This criterion describes how an alternative complies with the site-specific potential ARARs or whether a waiver

is required. Relevant advisories, criteria, and guidelines may also be considered.

Regulatory Agency Acceptance: This criterion evaluates the specific features of the alternatives that may be acceptable or not acceptable to the regulatory agencies.

Community Acceptance: This criterion evaluates the specific features of the alternatives that the community may support, have reservations about, or strongly oppose.

The first five criteria form the basis for the detailed evaluation. The next two criteria are concerned with the extent of human health and environmental protection and compliance with potential ARARs. These criteria are known as the threshold criteria and are required to be met by each alternative. The last two criteria reflect regulatory agency and community acceptance of the selected alternatives.

10.3 Remedial Alternative 1 - No Action

This remedial alternative features a no action response to groundwater and assumes that the existing interim soil remediation program would be terminated. It has been assumed that groundwater monitoring would continue for 30 years.

10.3.1 Long-Term Effectiveness and Permanence

No short or long term mitigation of conditions at the site would occur under Alternative 1. Under current conditions, no risk has been identified to onsite receptors for the complete pathways identified for the site. However, offsite migration of COPCs would continue and may pose an unacceptable risk to downgradient human and ecological receptors.

10.3.2 Reduction of Toxicity, Mobility, or Volume

Alternative 1 would not directly significantly reduce the toxicity, mobility, or volume of organic chemical-containing groundwater in the short term. Some attenuation of organic

chemical concentrations would be expected due to biodegradation and other degradation mechanisms.

10.3.3 Short-Term Effectiveness

Potential adverse effects on workers involved in groundwater monitoring could be mitigated by adopting appropriate health and safety procedures.

10.3.4 Implementability

The no action alternative could be implemented by terminating the existing interim SVE System and continuing regular groundwater monitoring.

10.3.5 Cost

The only costs associated with Alternative 1 are expected to be related to continued groundwater monitoring and decommissioning the interim SVE system.

10.3.6 Human Health/Environmental Protection

The no action alternative would not provide any greater protection of human health or the environment than that afforded by the existing surface pavement materials. Potential excess carcinogenic risks and noncarcinogenic health effects for downgradient human and ecological receptors are being evaluated in a separate PSA RA.

10.3.7 Compliance with ARARs

Alternative 1 does not comply with certain chemical, medium, or location-specific potential ARARs discussed in Section 8.1.2.1.

10.3.8 Regulatory Agency Acceptance

The no action alternative will likely not be acceptable to the regulatory agencies due to the continued downgradient migration of VOCs to offsite locations.

10.3.9 Community Acceptance

Alternative 1 may not be acceptable to the public for the reasons outlined in Section 10.3.8.

10.4 Remedial Alternative 2: Air Sparging and Vapor Extraction Combined with Groundwater Extraction and Treatment with Carbonaceous Adsorbent or Air Stripping

This alternative involves combining groundwater extraction and treatment utilizing either carbonaceous adsorbent or air stripping with air sparging and vapor extraction. The conceptual approach for implementing both remedial alternatives is presented in Section 11.0.

10.4.1 Long-Term Effectiveness and Permanence

The proposed groundwater remediation systems would be effective in the long-term and would provide a permanent remedy for the existing COPCs. The systems would serve the dual purpose of source control and preventing the migration of groundwater-borne contaminants to potential offsite receptors. In terms of reliability, the groundwater extraction system employs simple and well-proven technologies, and as such, is capable of providing the required degree of protection, if an adequate maintenance program is adopted. The expected maintenance requirements for the groundwater extraction/treatment system and air sparging system would be provided for this alternative in the Implementation and Monitoring Plan.

In addition, institutional controls could be used to prevent direct exposure to onsite groundwater. Institutional controls include a prohibition on installation of wells for drinking and irrigation purposes, the sanitary well seal requirements, site security, and worker training/hazard communication.

10.4.2 Reduction of Toxicity, Mobility, or Volume

The toxicity and volume of chemical-containing groundwater would be mitigated by extraction and treatment and air sparging. The mobility of the chemical constituents in groundwater could be severely reduced or eliminated, in that migration to potential downgradient receptors would be reduced or prevented. As groundwater would be extracted continuously, the mass of the chemical constituents dissolved in groundwater would be reduced.

10.4.3 Short-Term Effectiveness

Potential adverse effects on public health and the environment during implementation of Alternative 2 would be expected to be minimal and principally would be associated with the volatilization of VOCs during the installation of vapor and groundwater extraction wells and the treatment of groundwater. The volatilization of VOCs during well installation would be expected to be minimal and persist for a short time only. Accordingly, no significant health and/or environmental impacts would be anticipated. The use of the appropriate PPE could minimize the potential risk to workers involved in installation and operation of the remedial systems. The volatilization of VOCs to the atmosphere during SVE or groundwater treatment would be minimized by an appropriate vapor abatement/control device.

10.4.4 Implementability

The various components of Alternative 2 are well-proven and reliable technologies with few major unknown factors that could impact implementability. Unknown factors that could impact implementability (such as the effects of air channeling, radii of influence, and hydraulic effects on groundwater) will be evaluated through a pilot test. A work plan describing the proposed pilot test will be submitted to the Department for approval prior to conducting the test. After conducting pilot tests discussed in

Section 11.0, the implementability of the systems will be better understood. However, it is anticipated that both systems will be effective at remediating groundwater at the site.

10.4.5 Cost

The principal capital costs for this alternative would be for the installation of the additional sparging/vapor extraction wells and piping to the existing SVE treatment system, installation of additional extraction wells, as necessary, installation of the groundwater extraction and treatment system, effluent discharge piping and disposal fees, and real estate leasing. O&M costs include electrical and adsorbent costs, system maintenance, and ongoing sampling and reporting.

10.4.6 Human Health/Environmental Protection

Alternative 2 would substantially reduce the potential risk to downgradient human health and

the environment by reducing organic chemical concentrations in groundwater and by preventing or severely reducing the migration of groundwater-borne contaminants to potential offsite receptors.

10.4.7 Compliance with ARARs

This alternative complies with the potential ARARs for groundwater and air discussed in Section 8.1.2.1.

10.4.8 Regulatory Agency Acceptance

It is anticipated that Alternative 2 will be acceptable to the regulatory agencies.

10.4.9 Community Acceptance

It is anticipated that Alternative 2 will be acceptable to the general public.

11.0 RECOMMENDED REMEDIAL ACTION AND PROPOSED SUPPLEMENTAL ACTIVITIES

This section describes the conceptual approach for implementing the chosen remedial actions and describes additional activities to be conducted prior to designing the final remedial alternatives. The groundwater remediation system can be thought of as a two step process: source control and migration control. It is anticipated that air sparging and vapor extraction will be implemented downgradient of the 140 Milwaukee Avenue Area to prevent or severely reduce offsite migration of VOC-containing groundwater. Air sparging and vapor extraction are proposed as a supplemental action to groundwater extraction and treatment, the primary remedial action proposed for the Mall. Groundwater extraction and treatment, the primary remedial action, will be implemented at the former PCE AST location (at a minimum) to provide intensive source control. The necessity for additional groundwater extraction points will be assessed based on the results of an aquifer testing program to be implemented in the vicinity of the Pier 1 store, identification of groundwater discharge points, and gaining authorization to utilize these discharge points. The exact configuration of the remedial systems are not known at this time; rather this section presents the overall approach to remediation at the site. Following the testing phases described below, details of the systems will be provided in an Implementation and Monitoring Plan.

11.1 Groundwater Extraction and Treatment

11.1.1 Conceptual Approach

Source control is the key to efficient COPC remediation and minimizing long-term remedial activities. Because soil containing PCE in the vicinity of the former PCE AST has been remediated using the SVE system, the next step is to control and/or minimize the potential for contaminated groundwater to migrate from this source area. To perform groundwater source control and limit migration of the highest concentrations of PCE-impacted groundwater,

Well EW-1 will be used as a groundwater extraction well. Additional extraction wells may be installed after careful evaluation of data generated during the testing phases and continued evaluation of groundwater discharge options described in Section 11.1.5.

Groundwater extraction and treatment systems have been used for many years to remediate sites impacted by VOCs. However, use of extraction and treatment technology alone may not adequately address the removal of VOCs from subsurface soil particles that are in the saturated zone. The addition of vapor extraction capability to an extraction and treatment system allows dewatered soils to be exposed to the SVE system resulting in removal of adsorbed VOCs since VOCs partition more readily to air than water. Recovered VOCs can be removed from the vapor stream using carbon or other adsorption techniques. Because VW&R is proposing air sparging and vapor extraction at downgradient locations, and because an existing SVE system is already in place, enhancing an extraction and treatment system with wellhead vapor extraction can be easily accomplished and will be more effective than extraction and treatment alone. Additionally, groundwater flow into the well will be enhanced as a result of application of a vacuum to the wellhead.

Prior to completing the design of an effective groundwater extraction system, an aquifer testing program will be required to further characterize the hydraulic properties of the aquifer. Existing Well EW-1 will be utilized for the aquifer testing program (described below). Additionally, predictive modeling to estimate resultant capture zones will also be completed.

11.1.2 Aquifer Test

Because the highest concentrations of contaminants are in the shallow (upper 50 feet) portion of the aquifer, the critical aquifer testing phase will initially concentrate on the shallow portion of the aquifer in the vicinity of the Pier 1

store. The aquifer testing program will be expanded to the lower screened interval of Well EW-1 when the concentration of PCE in the upper screened interval has been reduced to similar concentrations as were found in the lower interval (i.e., approximately 400 $\mu\text{g/l}$) during the well construction activities. This precaution is necessary to prevent introduction of PCE-containing groundwater containing higher concentrations of PCE to the lower interval. An aquifer testing program consisting of a step-drawdown test and pumping test, will be conducted to: 1) evaluate optimum pumping rates; 2) evaluate the hydraulic characteristics of the aquifer; and, 3) provide the data necessary to predict the capture zone resulting from various pumping rates and well configurations. A work plan describing the details of the proposed aquifer test procedures will be submitted to the Department prior to initiation of aquifer testing. The aquifer testing program is described in general below.

The step drawdown test will be conducted by pumping the upper interval of Extraction Well EW-1 at several successively higher pumping rates and recording the resultant drawdown for each rate. The test will be conducted in a single day and the pumping times for each discharge rate will be the same. Up to five pumping rates will be used, each lasting 2 hours. Based on preliminary data obtained during development activities of Well EW-1, the production capability of the well's upper interval may be limited to 10 to 15 gpm. Therefore, the initial pumping rate for the step-drawdown test will be approximately 2 gallons per minute (gpm). Subsequent steps will be at approximately 2 gpm increments. Re-evaluation of the testing procedures may be required in the field after the step-drawdown test begins. Drawdown will be measured using a data logger and transducer installed in the extraction well. In addition, hand measurements will be made using an electric water level meter. The pumping rate will be measured using a commercially available meter.

Data obtained from the step-drawdown test will be evaluated using a graphical method such as that presented by Bierschenk (1964).

A 24-hour constant rate pumping test will be conducted after the water levels have returned to static conditions but no sooner than 12 hours following completion of the step-drawdown test on the same well utilized for the step drawdown test. The objective of the pumping test will be to characterize the hydraulic properties of the aquifer and will be accomplished by pumping the well at the optimum rate as determined from the step-drawdown test and measuring the resulting drawdown in the pumped well and nearby monitoring wells. Drawdown will be measured using a data logger and transducers installed in the extraction well and select monitoring wells. In addition, hand measurements will be made using an electric water level meter. The pumping rate will be measured using a commercially available meter.

A 12-hour recovery test will be conducted following the constant-rate pumping test. Recovery measurements will be made in the pumped well and monitoring wells at the same frequency as during the pumping portion of the aquifer test.

Should a constant rate test not be practical, a constant drawdown test will be conducted in the upper interval of Well EW-1. During well development activities, water in the upper interval of Well EW-1 was completely evacuated when pumped from 10 to 15 gpm. The constant drawdown test would be conducted by pumping groundwater from the upper interval of Well EW-1 and maintaining the water level within a predetermined depth range. Water level response in adjacent monitoring wells will be monitored. A transducer installed in the well will regulate the operation of the pump and be configured to maintain the water level at a minimum depth of approximately 40 feet.

Time-drawdown data collected during the constant-rate or constant drawdown pumping test will be evaluated using a solution developed by Theis (1935) or other applicable solution such as Hantush (1964a, b) to determine the aquifer's hydraulic characteristics.

11.1.3 Capture Analysis

A groundwater extraction system that is effective in achieving the objectives set forth in this RAP requires an understanding of the capture zone that results from pumping a well and how it compares with the desired capture width. To accomplish this, the hydraulic characteristics of the aquifer will be used in an analytical capture zone model to identify an effective extraction system configuration and predict the resultant capture zone. The extraction well(s) will then be pumped at the rate predicted by the model to achieve the desired capture zone. The effectiveness of the extraction system in creating the required capture zone will be confirmed through collection and evaluation of water level data from the system's groundwater monitoring wells.

11.1.4 Groundwater Extraction and Treatment System

The proposed treatment system will include facilities for the extraction and conveyance of groundwater, treatment of recovered groundwater, and discharge of treated water. The groundwater extraction portion of the system will include at least one extraction well and its transmission piping. Following evaluation of the aquifer test results and finalizing treated water discharge options, a final design for the groundwater extraction system will be prepared. At this time, VW&R anticipates treating the extracted groundwater using a carbonaceous adsorbent. However, air stripping has also been retained as a potential treatment process option. The discussion in the following section focuses on treatment using a carbonaceous adsorbent. If air stripping becomes the preferred alternative in the future, the Department will be notified and details of the system presented in the Implementation and Monitoring Plan.

11.1.4.1 Extraction System

An application will be made to the State of Idaho to appropriate public waters of the State upon finalizing the agreements with property owners where the extraction wells will be located. Each of the extraction wells will contain a submersible pump which will transmit groundwater to the

treatment system through a 4-inch diameter transmission line. A reinforced concrete vault will contain the well head, flow meter, associated piping, and an electrical disconnect for the well pump. Each well will be equipped with a transducer, located above the intake of the submersible pump. The transducer will continuously monitor the water level in the well and transmit the data to the treatment system.

11.1.4.2 Treatment System

The groundwater treatment portion of the system, to be sited at a location to be determined but anticipated to be in the vicinity of the Pier 1 store, will include an influent tank, a process feed pump, an inlet filter, adsorption vessels, a discharge filter, a holding tank, flow meters, a discharge pump, and discharge piping. An air compressor will provide power to operate valves and assist in periodic maintenance. The treatment equipment will be housed in a building that is aesthetically consistent with surrounding structures, and is equipped with personnel and service doors, heating and ventilation, an electrical and control cabinet, and maintenance and storage areas. The building's floor slab will be configured to provide secondary containment of the water treatment facilities within. The secondary containment will have a sump and pump to transfer wash water to the inlet tank.

The adsorption vessels will contain a carbonaceous adsorbent resin; however, in the event use of this resin becomes impractical, GAC will be substituted. Resins have unique properties that result in superior performance for a diverse range of liquid and vapor phase applications. One such application is groundwater remediation. Resin has several performance advantages over GAC which include:

- 5 to 10 times the sorption capacity of GAC for removal of VOCs
- Higher hydraulic loading rates (five to ten times higher) than are typical for GAC and maintenance of effluent water quality which meets drinking water standards

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- Not prone to bacterial fouling and are more resistant to fouling by naturally occurring organic matter such as humic and fulvic acids
- Can be regenerated in situ.

Extracted groundwater will be treated using resin to remove VOCs prior to its discharge.

The entire treatment process, from extraction through discharge, will be controlled and monitored by an onsite programmable logic controller (PLC). The PLC has been successfully implemented at other VW&R sites. The PLC is computer controlled and allows data to be obtained and recorded automatically from instruments and process control hardware. Similarly, the PLC can communicate with process control hardware to optimize system operation, detect alarm situations, and shut the entire system down if necessary. The PLC can be accessed by an offsite computer to acquire stored data. Control and data acquisition capabilities of the PLC are summarized as follows:

Process Control -

- Measure well water level
- Measure well discharge (flow) rate
- Measure influent tank liquid level
- Control process feed pump flow rate (by pump speed control)
- Measure pressure drop across the inlet filter
- Measure pressure drop across the VOC adsorption vessels
- Measure pressure drop across the outlet filter
- Measure liquid level in the secondary containment sump
- Operate the sump pump

Data Acquisition -

- Record well water level
- Record well discharge rate
- Record process feed pump operation hours
- Record pressure drop data

The treatment system will be configured with specific safeguards that will be continuously monitored by the PLC. Should a critical alarm condition occur, the PLC will automatically shut the entire system down and notify system operators of the faulty conditions. Safeguards,

described in more detail below, will include the following:

- Underground piping sloped toward the extraction wells
- Continuous monitoring of the underground piping and pumping system
- Sump float switch
- High level alarms
- Secondary containment within the treatment building
- Remote monitoring system

Underground piping used to transmit extracted groundwater to the treatment building will be sloped toward the extraction well(s) to allow evacuation of the piping in the event of a system shut down. Although underground piping will be installed below the frost line, implementation of this safeguard assures that piping breaks due to freezing water will not occur. The integrity of the piping will be monitored continuously by comparing the actual measured flow rate of fluid through the piping with the preset pumping rate. Differences between these parameters may indicate an integrity problem and would result in a system alarm and shutdown. Additionally, the amperage for the pump will be continuously monitored and, should anomalous readings be obtained, shut down of the system would occur.

The treatment equipment and building will be configured with safeguards that will shut down the entire system automatically should an alarm condition occur. For example, the treatment equipment will be housed within a building whose floor will be designed to serve as secondary containment. The floor of the building will be sloped toward a sump equipped with a sensor that will provide an alarm and shut the system down should water accumulate above a predetermined level. High level alarms and shut off will also be utilized on each water accumulation vessel.

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11.1.5 Groundwater Discharge Options

Once groundwater is treated, disposal of the treated water will be required. Disposal options need to be fully evaluated prior to selection and implementation of a final groundwater remediation system at the site. Due to the potentially large volume of water requiring treatment and discharge, discharge options could have an overwhelming influence on the remedial technology chosen. For example, if disposal options are limited or cost prohibitive, additional emphasis will likely be placed on an in situ air sparging and vapor extraction remedial alternative. A preliminary evaluation of disposal options include discharge to the storm drain, sanitary sewer, or reinjection.

11.1.5.1 Discharge to the Storm Drain

Effluent could be discharged to the storm drain system south of the Pier 1 Imports store which is operated by the Ada County Highway District. The storm water in turn is discharged to the Finch Drain. VW&R is currently discussing this alternative with the Ada County Highway District and the Nampa-Meridian Irrigation District, the operators of the Finch Drain. A NPDES permit may also be required for discharge of treated effluent to the Finch Drain.

11.1.5.2 Discharge to the Sanitary Sewer

Discharge to the sanitary sewer system would be governed by the West Boise Sewer District (WBSD) and the City of Boise. Based on conversations with Mr. Paul Kunz, WBSD Engineer, WBSD does not have established concentration requirements for VOCs. The City and WBSD indicated that discharge to the sanitary sewer should only be considered after all other alternatives were exhausted. Exorbitant connection fees to the WBSD system and extremely high costs due to the volume of water potentially requiring treatment rates make this disposal option unfeasible.

11.1.5.3 Reinjection

Injection of the treated groundwater upgradient of the Pier 1 Imports store and/or adjacent to the periphery of the affected area has several advantages and disadvantages. Advantages include the possible minimization of the groundwater removal from the system because all extracted groundwater would be reinjected, development of an upgradient hydraulic barrier to prevent potential upgradient contamination from migrating onsite, and potential creation of an increased hydraulic gradient that would accelerate groundwater movement toward Extraction Well EW-1. Upgradient injection will require access agreements to developed properties and will be difficult to obtain. Reinjection also requires intensive maintenance to be effective. Following the aquifer testing and capture analysis, a more detailed evaluation of injection as a disposal option will be performed, if necessary.

11.2 Air Sparging and Vapor Extraction

11.2.1 Conceptual Approach

As described in Section 8.3.3.2, air sparging can be best visualized as in situ air stripping. It consists of the injection of air into the saturated, VOC-affected aquifer (under carefully controlled conditions), to strip the VOCs from the aquifer (i.e., remove the VOCs from the groundwater into the air stream). The stripped VOCs are then captured in the overlying unsaturated soils using SVE. This technology is currently in use at many sites throughout the United States and has been shown to expedite the remedial process when compared to other available remedial processes. When properly applied, this technique can be more effective than traditional groundwater extraction and treatment technologies to remediate an area affected by VOC contamination in the saturated zone. Additionally, when applied properly, air sparging serves as an active barrier to prevent or severely reduce the further migration of VOC-affected groundwater. Air sparging and vapor extraction may act as an important supplement to groundwater extraction and treatment.

Potential locations for implementation of a full-scale air sparging system include:

- Downgradient portions of the site
- Area near Well EW-1 and adjacent areas to supplement groundwater extraction.

For air sparging to be successful, site conditions must be amenable to the technology. These conditions include:

- The VOCs present must be strippable
- The VOC-affected saturated material must be of sufficient permeability to allow air to distribute freely
- A sufficiently thick unsaturated zone must be present to allow for the capture of the stripped VOCs.

All of these conditions are present at the site; however, an air sparging pilot test is proposed to evaluate the applicability and site-specific effectiveness (including radii of influence) of this technology to site-specific conditions. A work plan for the pilot test will be submitted to the department for approval prior to conducting the test. A general description of procedures that are proposed for the pilot test is presented below.

11.2.2 Short Duration Design Test

In order to design an effective air sparging system, it is first necessary to conduct a short duration design test to determine operating parameters. Data collected from the short duration design test will then be utilized to design and implement a full scale air sparging system. A description of a conceptual approach for conducting a short duration air sparging test is provided below.

The short duration design test will consist of a soil vapor test followed by the air sparging test. The SVE test will be implemented by connecting the soil vapor extraction system to a vapor extraction point installed in one of the potential areas specified previously. The SVE system will be operated at a flow of between 75 to 100 actual cubic feet of air removed at the vapor extraction

point per minute. The zone of influence may be evaluated by monitoring air flow and/or absolute pressure at evaluation test points set at fixed distances from the extraction point. Also, the extracted gas stream will be monitored for VOC concentration using a field organic vapor analyzer.

The SVE system will operate until equilibrium is reached in the VOC concentration of the extracted stream. Field experience has shown that this will take between 1 to 4 hours. It is essential to establish an equilibrium baseline for VOCs in the extracted gas stream so that an accurate measure can be made of contributions of VOCs in the unsaturated zone prior to the start of the air sparging portion of the test. This will allow for an accurate measure of the amount of VOCs stripped from the saturated zone due to air sparging.

The air sparging portion of the test will be conducted by injecting air into a well which is screened across the affected zone of the aquifer. This well will be located within a radius of 30 feet of the vapor extraction point. Air will be injected into a zone 10 to 30 feet below the water table using a non-inflatable double packer type assembly and a 3/4-inch-diameter PVC or equal drop tube. The injection pressure(s) used during this test will depend upon the depth below the water table the air is injected and the resistance to flow encountered in the soil formation. It is estimated that the required injection pressure will be between 5 to 20 pounds per square inch gauge (psig). It may be possible to vary the injected air flow rates. Normally, a test of this type is operated at four different injection pressures at each volumetric flow rate to evaluate the most efficient pressure and flow combination to optimize VOC removal. For each injection flow and pressure combination, the test will continue until sufficient organic vapor measurements of air extracted by the vapor extraction test unit can be obtained to evaluate performance at these conditions.

Air for the air sparging test will be provided using a module test unit. This unit will consist of an oil free air compressor, a pressure storage, pressure relief valves, a pressure regulating valve, a temperature probe, pressure gauges, and an air

flow control rotameter. The temperature and pressure of air will be recorded for each flow rate so that the air flow can be corrected to standard conditions of temperature and pressure.

Monitoring of the air sparging test will consist of monitoring the extracted gas stream and the test evaluation points. The test evaluation points will consist of monitoring points completed both in the saturated and unsaturated zones.

For test points completed in the saturated zones, continuous water level measurements will be performed. This data will be used to detect localized upwelling in the water table due to the injected and extracted air. The extent of this upwelling can be used to evaluate the zone of influence of injected air.

For test evaluation points completed in the unsaturated zone, monitoring will consist of analyzing the soil gas with a field organic vapor analyzer. By analyzing the VOCs present in the soil gas throughout the test and comparing them to readings taken before startup, an evaluation

can be made of the zone of influence of both the soil vapor extraction system and of the air sparging system.

Vapors collected by the soil vapor extraction system will be passed through an activated carbon canister prior to discharge of treated vapor to the atmosphere. The performance of the activated carbon system will be monitored by analyzing the gas concentration of VOCs using an organic vapor analyzer both before and after carbon treatment. If the VOC concentration the discharge of the activated carbon system exceeds 4 PPM as measured by the field organic vapor analyzer, the air stream will be diverted to a standby activated carbon canister. Through the execution of this test, two activated carbon canisters will be connected to the test unit in parallel using piping and valves. In this manner, one carbon canister will be in use and the second will be on standby. The activated carbon canisters can be switched rapidly and without the need to stop the test should the air discharge exceed 4 PPM VOCs as measured by the field organic vapor analyzer.

12.0 SCHEDULE

A proposed schedule for finalization of the SI/RAP and implementation of the proposed remedial action is presented in Table 8.

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TABLES

Table 1. Background Groundwater Analytical Results

Report ¹ Section	Well Owner/ Consultant	Sampled By	Well Location	Sample Date	EPA Test Method	PCE Concentration (µg/l) ²	Other Detected VOCs ³ µg/l
2.2.1	Mervyn's	Dames & Moore	MW-1	2/89	601/602	ND	ND ⁴
	Mervyn's	Dames & Moore	MW-2U	2/89	601/602	ND	ND
	Mervyn's	Dames & Moore	MW-2L	2/89	601/602	ND	ND
	Mervyn's	Dames & Moore	MW-3U	2/89	601/602	ND	ND
	Mervyn's	Dames & Moore	MW-3L	2/89	601/602	ND	ND
2.2.5	State of Idaho	State of Idaho	State MW-1	7/91	502.2	656	TCE ⁵ - 39.8 Cis 1,2-DCE ⁶ - 10.6 ⁶
	State of Idaho	State of Idaho	State MW-2	7/91	502.2	15.4	1,1,1-TCA ⁷ - 0.59
	State of Idaho	State of Idaho	State MW-3	7/91	502.2	1.0	ND
	State of Idaho	State of Idaho	State MW-4	7/91	502.2	ND	ND
	State of Idaho	State of Idaho	State MW-1	10/91	502.2	7,370	TCE - 21.3 Cis 1,2-DCE - 16.8
	State of Idaho	State of Idaho	State MW-2	10/91	502.2	ND	ND
2.2.6	GZA	GZA	GZA-1	6/91	GC-Nonapproved EPA Test Method	ND	ND

**Table 1. Background Groundwater Analytical Results
(continued)**

Report ¹ Section	Well Owner/ Consultant	Sampled By	Well Location	Sample Date	EPA Test Method	PCE Concentration (µg/l) ²	Other Detected VOCs ³ µg/l
	GZA	GZA	GZA-2	6/91	GC-Nonapproved EPA Test Method	ND	ND
	GZA	GZA	GZA-3	6/91	GC-Nonapproved EPA Test Method	ND	ND
	GZA	GZA	GZA-4	6/91	GC-Nonapproved EPA Test Method	1,400	ND
	GZA	GZA	GZA-5	6/91	GC-Nonapproved EPA Test Method	56	ND
	GZA	GZA	GZA-6	6/91	GC-Nonapproved EPA Test Method	490	ND
2.2.7	State of Idaho	HLA	State MW-1	9/91	8010	5,100	TCE - 70 Total 1,2-DCE - 63
	State of Idaho	HLA	State MW-2	9/91	8010	6.1	1,1,1-TCA - 2.0
	State of Idaho	HLA	State MW-3	9/91	8010	ND	ND
2.2.9	GZA	IHI	GZA-1	6/92	8010	Dry	Dry
	GZA	IHI	GZA-2	6/92	8010	ND	ND
	GZA	IHI	GZA-3	6/92	8010	ND	ND
	GZA	IHI	GZA-4	6/92	8010	2,500	TCE-45 Cis 1,2-DCE - 150
	GZA	IHI	GZA-5	6/92	8010	1,100	ND

Table 1. Background Groundwater Analytical Results
(continued)

Report ¹ Section	Well Owner/ Consultant	Sampled By	Well Location	Sample Date	EPA Test Method	PCE Concentration ($\mu\text{g/l}$) ²	Other Detected VOCs ³ $\mu\text{g/l}$
	GZA	IHI	GZA-6	6/92	8010	400	ND

1 Indicates section of report that discusses results

2 $\mu\text{g/l}$ - micrograms per liter

3 VOCs - Volatile organic compounds

4 ND - Not detected

5 TCE - Trichloroethene

6 Cis 1,2-DCE - Cis-1,2 dichloroethene

7 1,1,1-TCA - 1,1,1-trichloroethane

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Table 2. Soil Sampling Analytical Results, June 1989

Boring Number	Depth (feet)	Detected 8240 Analytes			
		1,2-DCE (Total)	PCE	TCE	Toluene
B1	5	3.1	17	1.7	<0.05
	8.5	0.17	1.4	0.17	0.11
	12	<0.05	0.74	0.05	0.11
B1A	10.5	<0.05	0.16	<0.05	<0.05
B1A	10.5D	<0.05	0.11	<0.05	<0.05
B1A	FB	<0.05	<0.05	<0.05	<0.05
B2	5	<0.05	1.1	<0.05	0.13
B2	10.5	<0.05	<0.05	<0.05	0.11
B2	12	<0.05	<0.05	<0.05	0.11

Notes: Analytical results in milligrams per kilogram (mg/kg)
Toluene detected in laboratory reagent blank
< indicates sample below stated detection limit
FB indicates Field Blank
D indicates duplicate sample
Data collected by Geraghty & Miller, Inc.

Table 3. Soil Gas Analytical Results, September 13-17, 1991
140 Milwaukee Avenue Area
Boise, Idaho

Sample	Depth (feet)	Vinyl Chloride ($\mu\text{g/l}$) ¹	Trans- DCE ($\mu\text{g/l}$)	Cis- DCE ($\mu\text{g/l}$)	TCE ($\mu\text{g/l}$)	PCE ($\mu\text{g/l}$)	Total Hydrocarbons ($\mu\text{g/l}$)	Other Detected Compounds ($\mu\text{g/l}$)
FB13SEP#1 ²		<0.01	<0.01	<0.01	<0.01	<0.01	<1.0	
FB15SEP#1		<0.01	<0.01	<0.01	<0.01	<0.01	<1.0	
FB16SEP#1		<0.01	<0.01	<0.01	<0.01	<0.01	<1.0	
FB16SEP#2		<0.01	<0.01	<0.01	<0.01	<0.01	<1.0	
SG-01-A	7.5	<0.01	<0.01	<0.01	0.16	2.20	25	
SG-01-B	7.5	<0.01	<0.01	<0.01	0.12	2.40	15	
SG-02-A	9.0	<0.01	<0.01	<0.01	<0.01	26.00	38	
SG-02-B	9.0	<0.01	<0.01	<0.01	0.03	28.00	42	
SG-03	9.0	<0.01	<0.01	<0.01	<0.01	<0.01	23	
SG-04	6.7	<0.01	<0.01	<0.01	<0.01	<0.01	9	
SG-05	11.0	<0.01	<0.01	<0.01	0.04	0.14	22	
SG-06	7.0	<0.01	<0.01	<0.01	<0.01	0.11	13	
SG-07-A	8.5	<0.01	<0.01	<0.01	<0.01	<0.01	10	
SG-07-B	8.5	<0.01	<0.01	<0.01	<0.01	<0.01	13	
SG-08	5.0	<0.01	<0.01	<0.01	<0.01	<0.01	7	
SG-09	5.5	<0.01	<0.01	0.60	9.30	350.00	230	
SG-10	7.0	5.80	2.20	74.00	70.00	1,400.00	6200	Ethylbenzene (250)
SG-11	5.5	3.30	0.71	57.00	38.00	1,100.00	2600	Ethylbenzene (140)
SG-12	9.0	<0.01	<0.01	120.00	1,800.00	4,600.00	55000	Ethylbenzene (730)
SG-13-A	8.0	<0.01	<0.01	17.00	57.00	1,300.00	2,500	Unknown Aromatic
SG-13-B	8.0	<0.01	<0.01	<0.01	6.20	340.00	320	Unknown Aromatic
SG-14-A	6.5	<0.01	<0.01	290.00	170.00	5,500.00	21,000	Ethylbenzene (630)
SB-14-B	6.5	<0.01	<0.01	380.00	150.00	5,300.00	20,000	Ethylbenzene (1200)
SG-15	6.0	<0.01	<0.01	540.00	380.00	5,500.00	20,000	Ethylbenzene (830)
SG-16	9.0	<0.01	<0.01	<0.01	11.00	900.00	1400	Ethylbenzene (2)
SG-17	9.0	<0.01	<0.01	<0.01	<0.01	<0.01	60	Ethylbenzene (2)
SG-18	9.0	<0.01	<0.01	<0.01	<0.01	8.00	59	Ethylbenzene (2)

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Table 3. Soil Gas Analytical Results, September 13-17, 1991
140 Milwaukee Avenue Area
Boise, Idaho
(continued)

Sample	Depth (feet)	Vinyl Chloride (µg/l) ¹	Trans- DCE (µg/l)	Cis- DCE (µg/l)	TCE (µg/l)	PCE (µg/l)	Total Hydrocarbons (µg/l)	Other Detected Compounds (µg/l)
SG-19	6.0	<0.01	<0.01	18.00	<0.01	290.00	320	Ethylbenzene (2)
SG-20	9.0	<0.01	<0.01	400.00	460.00	5,100.00	53,000	Ethylbenzene (620)
SG-21	5.5	<0.01	<0.01	<0.01	14.00	620.00	500	
SG-22-A	7.0	<0.01	<0.01	<0.01	9.10	420.00	290	
SG-22-B	7.0	<0.01	<0.01	<0.01	<0.01	350.00	220	
SB-23	7.5	<0.01	<0.01	<0.01	<0.01	<0.01	26	
SB-24	7.5	<0.01	<0.01	<0.01	<0.01	<0.01	25	
SB-25-A	5.5	<0.01	<0.01	12.00	17.00	1,100.00	1,500	
SG-25-B	5.5	<0.01	<0.01	9.40	18.00	1,000.00	1,400	
SG-26	7.0	<0.01	<0.01	<0.01	11.00	230.00	560	
SG-27	7.0	<0.01	<0.01	<0.01	<0.01	<0.01	<1.0	No Surrogate
SG-28	9.0	<0.01	<0.01	<0.01	<0.01	<0.01	37	
SG-29	9.0	<0.01	<0.01	<0.01	62.00	940.00	1100	
SG-30	7.5	<0.01	<0.01	<0.01	<0.01	710.00	630	
SG-31	9.0	<0.01	<0.01	<0.01	<0.01	640.00	610	
SG-32-A	5.0	<0.01	<0.01	<0.01	<0.01	40.00	42	
SG-32-B	5.0	<0.01	<0.01	<0.01	<0.01	32.00	36	
SG-33	9.0	<0.01	<0.01	<0.01	<0.01	2.40	32	
SG-34	7.0	<0.01	<0.01	<0.01	18.00	660.00	600	
WATER		<0.01	<0.01	<0.01	<0.01	39.00	100	

1 µg/l Micrograms per liter

2 FB13SEP#1 Field blank

3 Water sample collected from decontamination and purge water, analyzed by mobile laboratory

Table 4. Soil Sample Analytical Results, October 22, 1991
140 Milwaukee Avenue area
Boise, Idaho

Sample Number	Boring/Depth (feet)	Detected 8010/8020 Analytes ¹						TPH ¹		Moisture (%)	Grain Size Classification ⁵
		PCE	TCE	Methylene-Chloride ²	Carbon Tetrachloride	cis-1,2 DCE	1,1,1 TCA	Gasoline	Diesel		
91102204	B-1, 5.5	26,000	3.1	0.75	<0.05 ⁶	1.3	<0.05	<5	<5	15	CH
91102205	B-1, 8.0	3,090	<5	<5	<5	<5	<5	NA ⁴	NA	NA	NA
91102206	B-1, 9.5	3,000	0.4	0.73	0.18	<0.05	<0.05	<5	<5	4.1	SP-SC
91102209 ³	B-1, 13.5	1,100	<0.05	0.76	<0.05	<0.05	<0.05	<5	<5	11	GW
91102211 ³	B-2, 4.5	3,300	1.5	0.63	<0.05	0.52	<0.05	<5	<5	18	CH
91102215 ³	B-2, 9	840	0.51	0.65	<0.05	<0.05	<0.05	<5	<5	4.7	CH (at 6.5 feet)
91102216	B-2, 8.5	3,100	<5	<5	<5	<5	<5	NA	NA	NA	NA
91102218	B-2, 12.5	4.0	<0.01	0.20	<0.01	0.014	<0.01	<5	<5	11	SC
91102220	B-3, 4	0.23	<0.01	0.22	<0.01	<0.01	<0.01	<5	<5	7.5	SP-SC
91102222	B-3, 8	0.68	<0.01	0.32	<0.01	<0.01	0.016	<5	<5	11	SC
91102224	B-3, 12	0.014	<0.01	0.16	<0.01	<0.01	<0.01	<5	<5	3.5	SP
91102229	B-4, 5.5	0.05	<0.01	0.23	<0.01	<0.01	<0.01	<5	<5	15	CH
9102233	B-4, 10	0.86	<0.05	1.1	<0.05	<0.05	<0.05	<5	<5	5.3	GP-GC
9102233	B-4, 14	0.21	<0.01	0.15	<0.01	<0.01	<0.01	<5	<5	13	SC

- 1 Concentrations expressed in milligrams per kilogram (mg/kg).
- 2 Analyte was found in the associated blank as well as the samples.
- 3 Surrogate percent recovery for bromochloromethane is out of acceptable limits.
- 4 NA: Not analyzed
- 5 Refer to Unified Soil Classification System for soil type.
- 6 < indicates value was not detected at or above stated detection limit.

**Table 5. Soil Sample Analytical Results, February 23, 1994
140 Milwaukee Avenue Area
Boise, Idaho**

Sample Number	Depth (Feet)	Detected 8010 Analytes	Detected 8020 Analytes
B9401-04	9.5-10	ND	ND
B9401-05	11.5-12	ND	ND
B9402-02	5.5-6	ND	ND
B9402-06	13.5-4	ND	ND
B9403-03	6.5-7	ND	ND
B9403-04	9.5-10	ND	ND
B9404-03	7.5-8	ND	ND
B9404-05	11.5-12	ND	ND
B9405-01	3.5-4	PCE: 0.11	ND
B9405-02	5.5-6	PCE: 0.088	ND

ND: Not detected
Results in: Milligrams per kilogram (mg/kg)

Table 6. Initial Screening of Groundwater Remediation Technologies and Process Options

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
No Action	None	Not Applicable	No Action	Required for consideration by NCP
Containment	Physical Containment	Slurry Cutoff Wall	Trench around perimeter of contaminated area is keyed into low permeability stratum and filled with a low permeability slurry	Not feasible due to depth of stratum in which to key trench and numerous surface obstructions
		Grout Curtain	Low permeability grout injected into formation via series of borings around perimeter of contaminated area to form continuous vertical barrier	Not feasible due to depth of stratum in which to key trench and numerous surface obstructions
		Sheet Pile Wall	Interlocking steel piles are driven around perimeter of contaminated area to form continuous vertical barrier	Not feasible due to depth of stratum in which to key piles and numerous surface obstructions
In-Situ Remediation	Hydraulic Containment	Extraction Barrier	Overlapping cones of depression around series of wells creates continuous barrier	Technically feasible and potentially applicable in conjunction with groundwater treatment
	Chemical Treatment	Chemical Treatment	Organic chemicals mobilized or degraded by a chemical treatment agent delivered to the aquifer	Not feasible due to non-uniform delivery and uncertain by-products
	Biological Treatment	Bioremediation	Biological degradation enhanced by the addition of nutrients, oxygen, and sometimes microorganisms	Not feasible due to presence of chlorinated compounds
	Vapor Extraction	Vapor Extraction	VOCs volatilized from soil and groundwater matrices using an induced air current	Technically feasible and potentially applicable when used in conjunction with air sparging
	Air Sparging and Vapor Extraction	Air Sparging and Vapor Extraction	Air injection into aquifer mobilizes VOCs into the vadose zone where they are removed using SVE	Technically feasible and potentially applicable
Removal	Extraction and Treatment	Air Stripping	Groundwater extracted from wells and treated by air stripping prior to discharge	Technically feasible and potentially applicable
		Carbonaceous Adsorption	Groundwater extracted from wells and treated by carbonaceous adsorption prior to discharge	Technically feasible and potentially applicable
		Air Stripping and Carbonaceous Adsorption	Groundwater extracted from wells and treated by air stripping and carbonaceous adsorption in series prior to discharge	Technically feasible and potentially applicable
		Chemical/Ultraviolet Oxidation	Groundwater extracted from wells and treated by chemical/ultraviolet oxidation prior to discharge	Not feasible due to presence of high VOC concentrations
		Bioremediation	Groundwater extracted from wells and treated by bio-oxidation prior to discharge	Not feasible due to presence of chlorinated organic compounds

NOTE: Shading indicates that the process option has been eliminated from further consideration

Table 7. Screening of Groundwater Remediation Technologies and Process Options

General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability	Relative Cost
No Action	None	Not Applicable	Does not achieve remedial action objectives or target remedial goals	No site disturbance; unlikely to be implementable from an administrative perspective	Capital and O&M costs low; overall costs low
Containment	Hydraulic Containment	Extraction Barrier	Can effectively prevent potential exposure to off-site receptors.	Very little site disturbance and simple technology; must be performed in conjunction with a treatment technology	Capital and O&M costs moderate; overall costs moderate to high due to duration (see extraction and on-site treatment)
In-Situ Remediation	Air Sparging and Vapor Extraction	Air Sparging and Vapor Extraction	Capable of achieving the target remedial goals	Little site disturbance associated with implementation; SVE system already operational; technology relatively new but increasingly accepted	Capital and O&M costs moderate; overall costs moderate
Removal	Extraction and On-Site Treatment	Air Stripping	Capable of achieving the target remedial goals and NPDES discharge limits	Little site disturbance associated with implementation; technology well proven and generally accepted	Capital and O&M costs moderate; overall costs moderate
		Carbonaceous Adsorption	Capable of achieving the target remedial goals and NPDES discharge limits	Little site disturbance associated with implementation; technology well proven and generally accepted	Capital and O&M costs moderate; overall costs moderate
		Air Stripping and Carbonaceous Adsorption	Capable of achieving the target remedial goals and NPDES discharge limits; added degree of protection is minimal	Little site disturbance associated with implementation; technology well proven and generally accepted	Capital and O&M costs moderate; overall costs moderate
		Chemical/Ultraviolet Oxidation	Potentially capable of achieving the target remedial goals and NPDES discharge limits	Little site disturbance associated with implementation; technology relatively new but increasingly accepted	Capital and O&M costs high; overall costs high

NOTE: Shading indicates that the process option has been eliminated from further consideration

Table 8. Boise Mall Order Schedule

Activity	Schedule Dependency	Estimated Start Date	Estimated Completion Date	Comments
Draft Mall SI/RAP		27-Jul-94	27-Jul-94	Actual submittal on 27-Jul-94
Draft Final Mall SI/RAP	Dependent on resolution of comments.	2-Sep-94	3-Nov-94	Actual submittal on 2-Nov-94
Public Comment Period		9-Nov-94	9-Dec-94	Comment period may be extended for an additional 30 days
Response to Public Comments	Dependent on receipt of comments from IDEQ	30-Dec-94	12-Jan-95	Department letter received 29-Dec-94; Response to Comments letter dated 12-Jan-95
Final Mall SI/RAP	14 days from Department approval of Response to comments	27-Jan-95	31-Jan-95	Verbal approval of Response to Comments letter 27-Jan-95
Draft Remedial Action Implementation Monitoring Plan (RAIM Plan)	45 days after Final Mall SI/RAP approval received from IDEQ	2-Mar-95	17-Apr-95	Assumes 30-day IDEQ review and approval prior to beginning of 45-day period Dependent on completion of pilot tests described in RAP (Access dependent)
Final RAIM Plan	14 days after Department approval of Draft RAIM Plan	17-May-95	31-May-95	Assumes 30-day IDEQ review and approval period
Implement Remedial Action	Within the time frame set forth in the RAIM Plan	31-May-95		

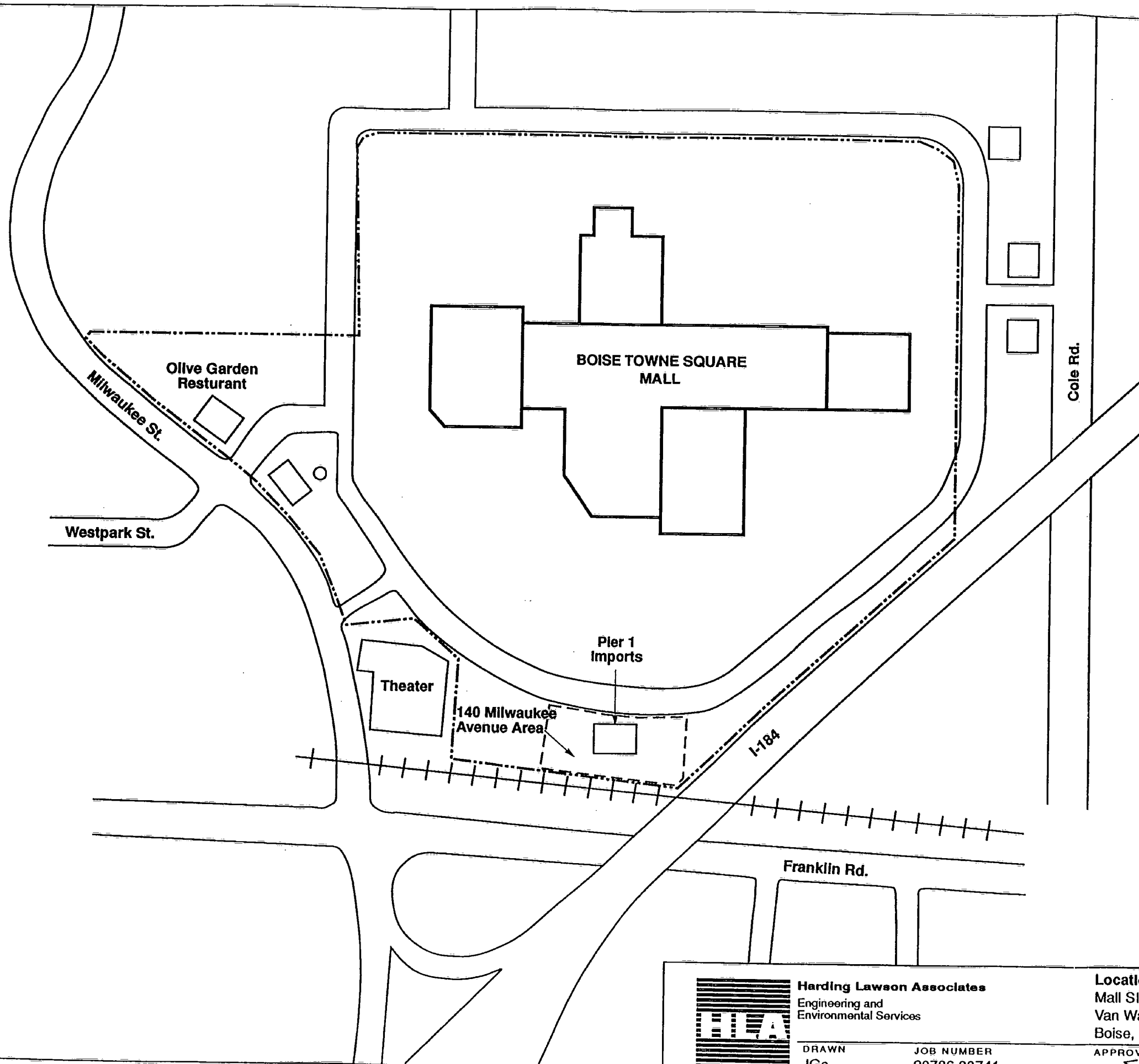
Notes:

1. Assumes a 30-day approval process by IDEQ
2. Actual dates will be updated on a quarterly basis as the task date approaches

1/27/95

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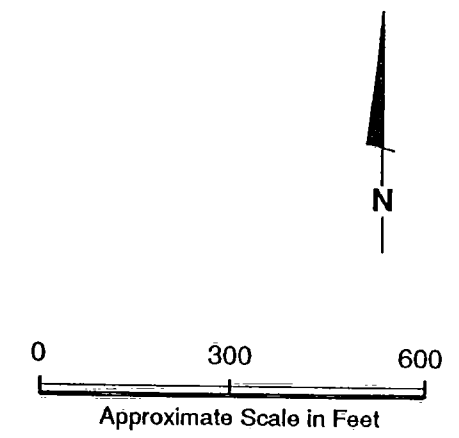
PLATES



EXPLANATION

--- Approximate 140 Milwaukee Avenue Area Boundary

..... Approximate Site Boundary



Harding Lawson Associates
Engineering and
Environmental Services

Location Map
Mall SI/RAP
Van Waters & Rogers Inc.
Boise, Idaho

DRAWN
JGc

JOB NUMBER
20786 00741

APPROVED
SmB

DATE
4/94

REVISED DATE

070784SE

PLATE

1

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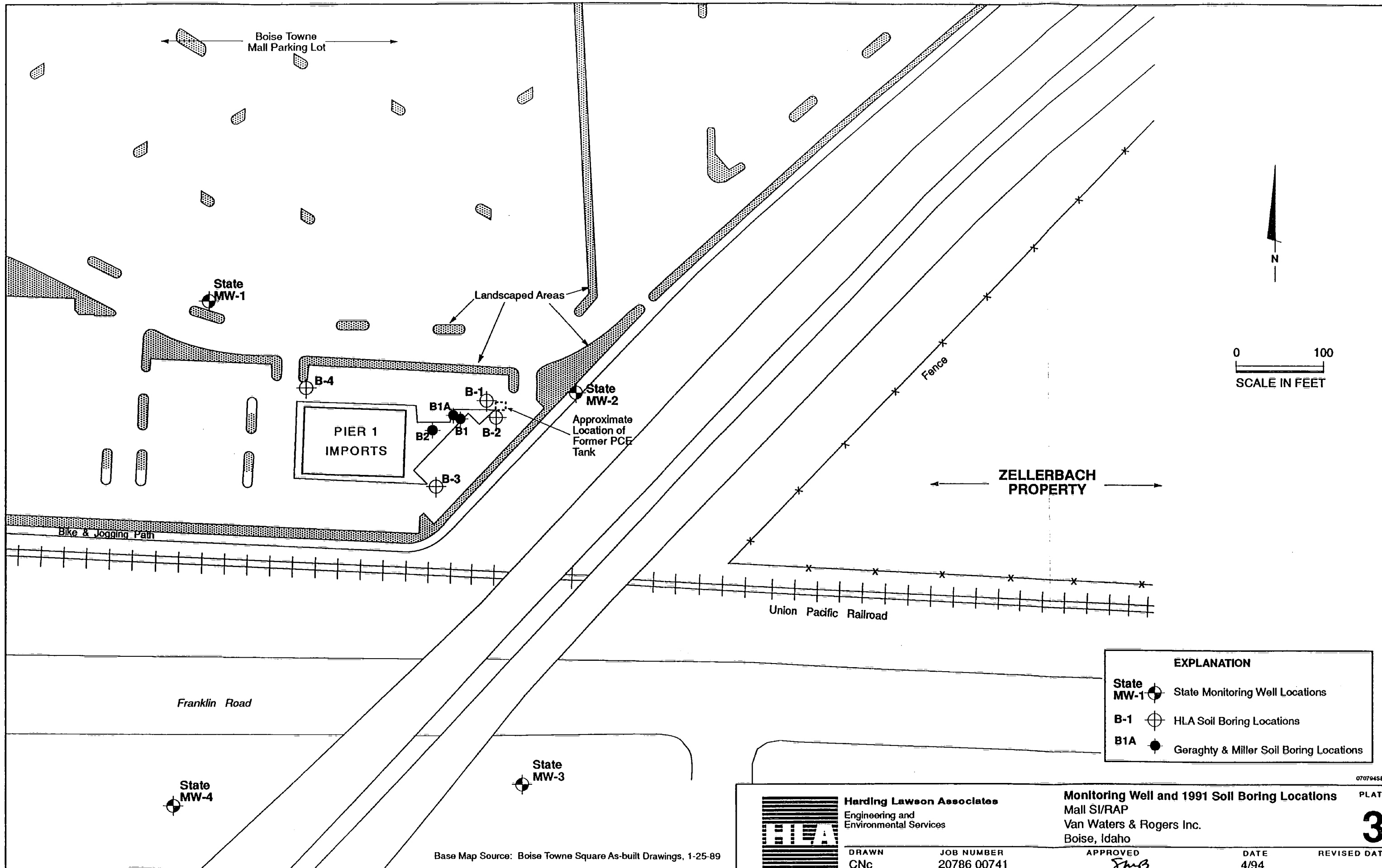
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Region 10
1200 Sixth Ave.
Seattle, WA 98101



EXPLANATION	
State MW-1	State Monitoring Well Locations
B-1	HLA Soil Boring Locations
B1A	Geraghty & Miller Soil Boring Locations

Base Map Source: Boise Towne Square As-built Drawings, 1-25-89



Harding Lawson Associates
Engineering and
Environmental Services

Monitoring Well and 1991 Soil Boring Locations
Mall SI/RAP
Van Waters & Rogers Inc.
Boise, Idaho

PLATE

3

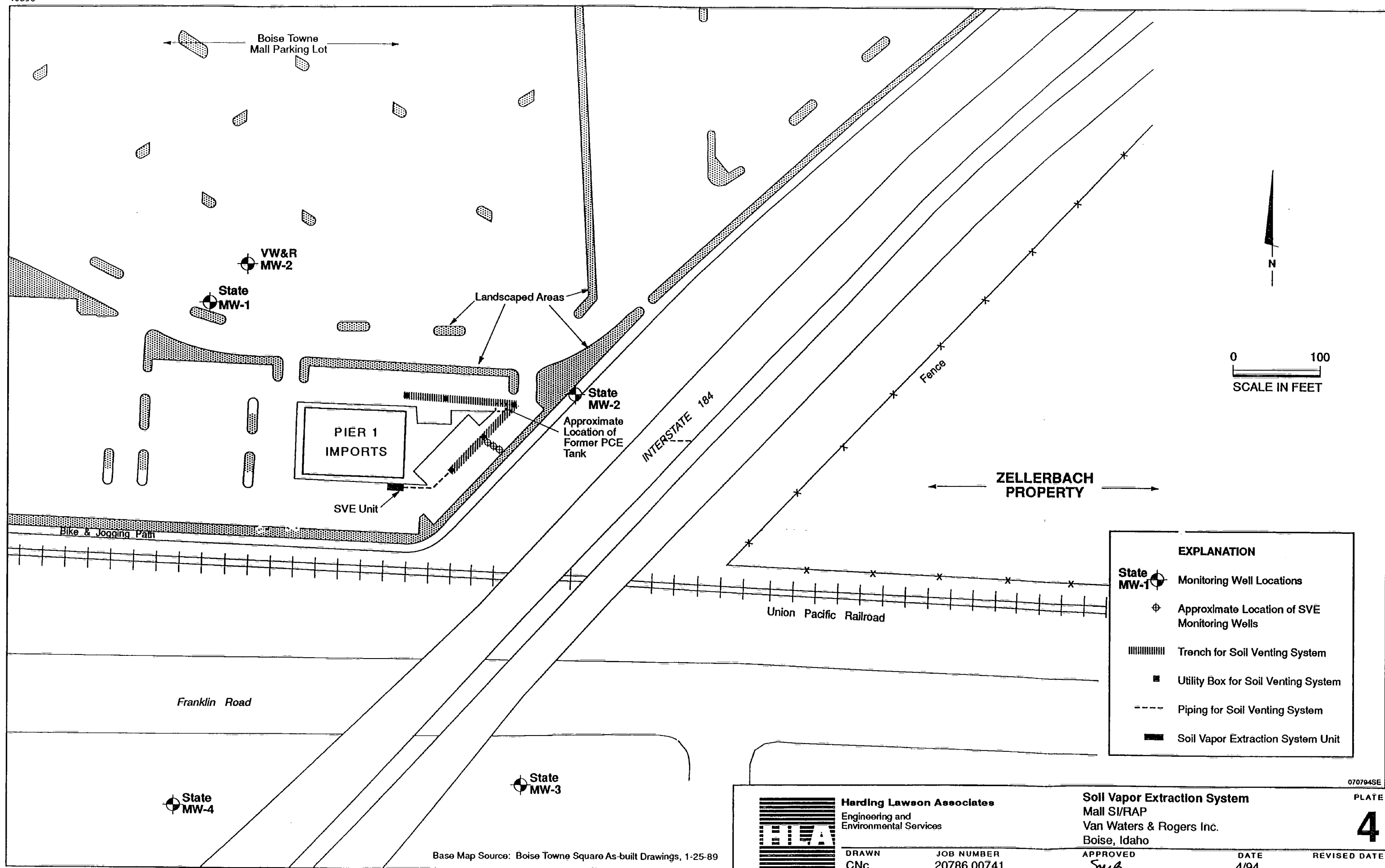
DRAWN
CNC

JOB NUMBER
20786 00741

APPROVED
JMB

DATE
4/94

REVISED DATE



EXPLANATION

- State MW-1 Monitoring Well Locations
- ⊕ Approximate Location of SVE Monitoring Wells
- ||||| Trench for Soil Venting System
- Utility Box for Soil Venting System
- Piping for Soil Venting System
- Soil Vapor Extraction System Unit



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Environmental Services

Soil Vapor Extraction System
Mall SI/RAP
Van Waters & Rogers Inc.
Boise, Idaho

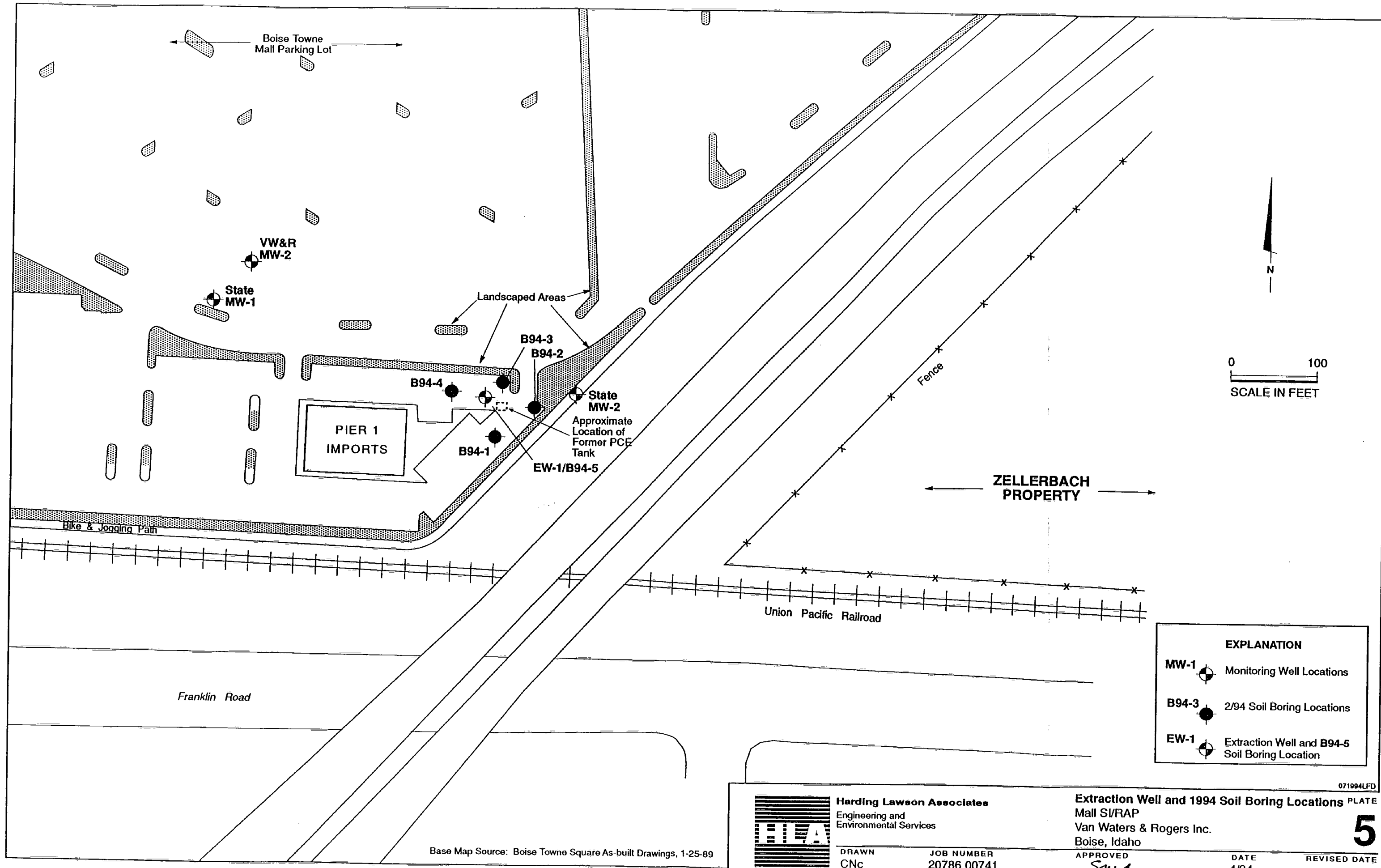
DRAWN
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JOB NUMBER
20786 00741

APPROVED
SMB

DATE
4/94

REVISED DATE



Harding Lawson Associates
Engineering and
Environmental Services

DRAWN
CNC

JOB NUMBER
20786 00741

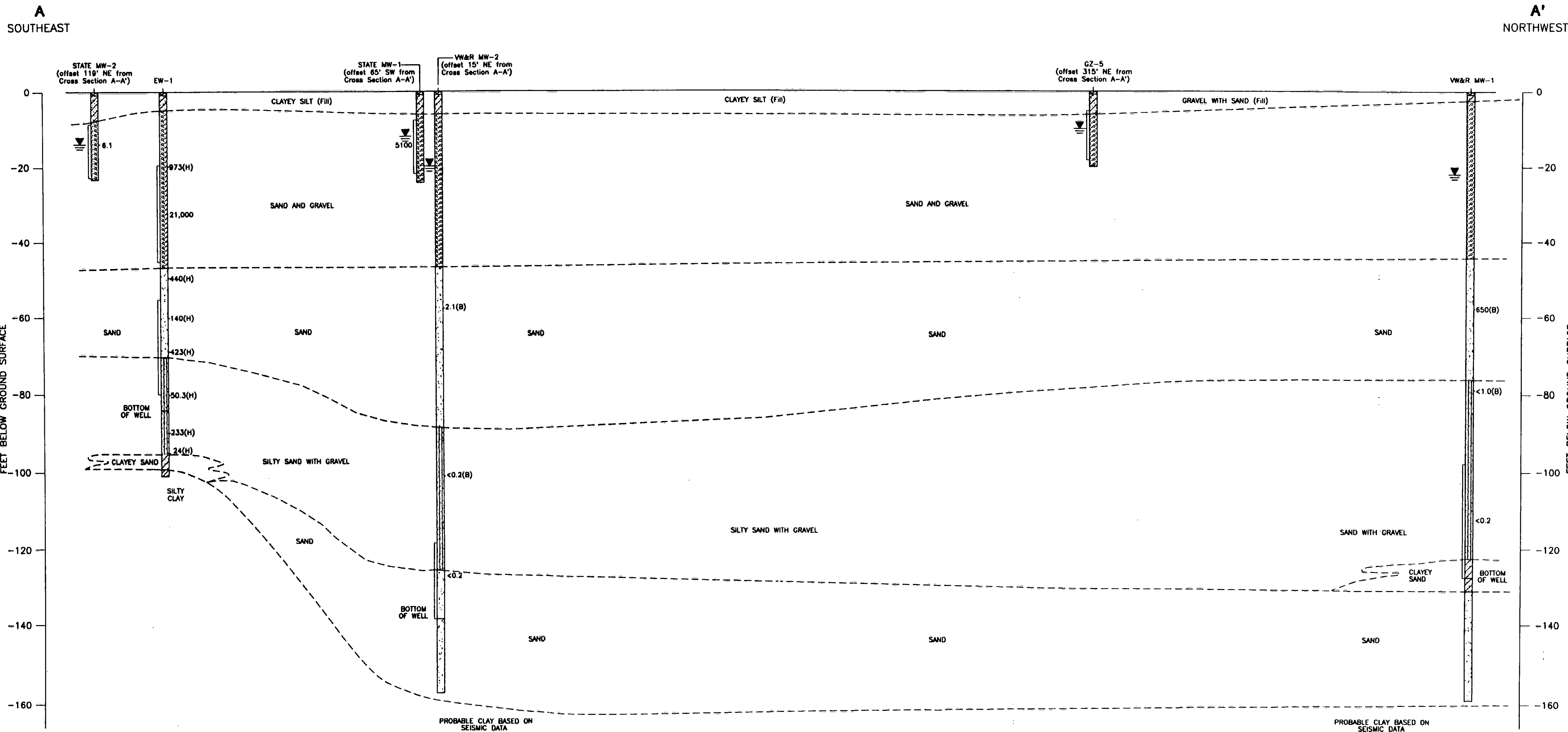
Extraction Well and 1994 Soil Boring Locations PLATE
Mall S/RAP
Van Waters & Rogers Inc.
Boise, Idaho

APPROVED
Sm

DATE
4/94

REVISED DATE

071994LFD



EXPLANATION

- GZ-5 MONITORING WELL DESIGNATION
- INFERRED CONTACT BETWEEN SOIL TYPES
- Fill ARTIFICIAL FILL MATERIAL
- ACTUAL LOCATION OF MONITORING WELL; THE DIAMETER OF THE LOG ON THE CROSS SECTION IS NOT TO SCALE.
- || MONITORING WELL SCREENED INTERVAL
- ▽ GROUNDWATER FIRST ENCOUNTERED
- 650 CONCENTRATION OF TETRACHLOROETHYLENE IN GROUNDWATER (micrograms per liter)
(H) INDICATES HYDROPUNCH SAMPLE
(B) INDICATES BAILEY SAMPLE
- ASPHALT
- CLAYEY SILT (Fill)
- SAND AND GRAVEL
- SAND
- SILTY SAND WITH GRAVEL
- CLAYEY SAND
- CLAY

0 100 200
SCALE IN FEET

VERTICAL EXAGGERATION = 5x
(VERTICAL SCALE = 20 FEET/INCH)

20786-001 1.0
12/25/02 1532

APPENDIX A
RESULTS OF CHEMICAL ANALYSES
FOR VOCs IN SOIL

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mall Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	Benzene	Bromo benzene	Bromochloro methane	Bromo dichloro methane	Bromoform	Bromomethane	n-Butyl benzene	sec-Butyl benzene
B-1	5.5	10/22/91	8010/8020	< 0.13	--	--	< 0.05	< 0.05	< 0.25	--	--
	8	10/22/91	8021	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	9.5	10/22/91	8010/8020	< 0.13	--	--	< 0.05	< 0.05	< 0.25	--	--
	13.5	10/22/91	8010/8020	< 0.13	--	--	< 0.05	< 0.05	< 0.25	--	--
B-2	4.5	10/22/91	8010/8020	< 0.13	--	--	< 0.05	< 0.05	< 0.25	--	--
	9	10/22/91	8010/8020	< 0.13	--	--	< 0.05	< 0.05	< 0.25	--	--
	8.5	10/22/91	8021	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	12.5	10/22/91	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.05	--	--
B-3	4	10/22/91	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.05	--	--
	8	10/22/91	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.05	--	--
	12	10/22/91	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.05	--	--
B-4	5.5	10/22/91	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.05	--	--
	10	10/22/91	8010/8020	< 0.13	--	--	< 0.05	< 0.05	< 0.25	--	--
	14	10/22/91	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.05	--	--
B9401-04	10	2/24/94	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.05	--	--
B9401-05	12	2/24/94	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.05	--	--
B9402-02	6	2/24/94	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.06	--	--
B9402-06	14	2/24/94	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.05	--	--
B9403-03	7	2/24/94	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.06	--	--
B9403-04	10	2/24/94	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.05	--	--

Notes:

All concentrations reported in milligrams per liter (mg/kg).
 < indicates value was not detected at or above stated detection limit.
 Dashes (--) indicate that no analysis performed for this entry.
 D indicates a duplicate sample.

Qualifiers:

J3: Indicates compound result is qualified as estimated due to noncompliance with spike recovery criteria.
 U1: Indicates compound result is qualified as non-detect due to its occurrence in laboratory blank.

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mall Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	Benzene	Bromo benzene	Bromochloro methane	Bromo dichloro methane	Bromoform	Bromomethane	n-Butyl benzene	sec-Butyl benzene
B9404-03	8	2/24/94	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.06	--	--
B9404-05	12	2/24/94	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.06	--	--
B9405-01	4	2/24/94	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.06	--	--
B9405-02	6	2/24/94	8010/8020	< 0.03	--	--	< 0.01	< 0.01	< 0.06	--	--

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mail Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	tert-Butyl benzene	Carbon tetra chloride	Chloro benzene	Chloroethane	Chloroform	Chloro methane	2-Chloro toluene	4-Chloro toluene
B-1	5.5	10/22/91	8010/8020	--	< 0.05	< 0.13	< 0.25	< 0.05	< 0.50	--	--
	8	10/22/91	8021	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	9.5	10/22/91	8010/8020	--	0.18	< 0.13	< 0.25	< 0.05	< 0.50	--	--
	13.5	10/22/91	8010/8020	--	< 0.05	< 0.13	< 0.25	< 0.05	< 0.50	--	--
B-2	4.5	10/22/91	8010/8020	--	< 0.05	< 0.13	< 0.25	< 0.05	< 0.50	--	--
	9	10/22/91	8010/8020	--	< 0.05	< 0.13	< 0.25	< 0.05	< 0.50	--	--
	8.5	10/22/91	8021	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	12.5	10/22/91	8010/8020	--	< 0.01	< 0.03	< 0.05	< 0.01	< 0.10	--	--
B-3	4	10/22/91	8010/8020	--	< 0.01	< 0.03	< 0.05	< 0.01	< 0.10	--	--
	8	10/22/91	8010/8020	--	< 0.01	< 0.03	< 0.05	< 0.01	< 0.10	--	--
	12	10/22/91	8010/8020	--	< 0.01	< 0.03	< 0.05	< 0.01	< 0.10	--	--
B-4	5.5	10/22/91	8010/8020	--	< 0.01	< 0.03	< 0.05	< 0.01	< 0.10	--	--
	10	10/22/91	8010/8020	--	< 0.05	< 0.13	< 0.25	< 0.05	< 0.50	--	--
	14	10/22/91	8010/8020	--	< 0.01	< 0.03	< 0.05	< 0.01	< 0.10	--	--
B9401-04	10	2/24/94	8010/8020	--	< 0.01	< 0.03	< 0.05	< 0.01	< 0.10	--	--
B9401-05	12	2/24/94	8010/8020	--	< 0.01	< 0.03	< 0.05	< 0.01	< 0.10	--	--
B9402-02	6	2/24/94	8010/8020	--	< 0.01	< 0.03	< 0.06	< 0.01	< 0.12	--	--
B9402-06	14	2/24/94	8010/8020	--	< 0.01	< 0.03	< 0.05	< 0.01	< 0.10	--	--
B9403-03	7	2/24/94	8010/8020	--	< 0.01	< 0.03	< 0.06	< 0.01	< 0.11	--	--
B9403-04	10	2/24/94	8010/8020	--	< 0.01	< 0.03	< 0.05	< 0.01	< 0.11	--	--
B9404-03	8	2/24/94	8010/8020	--	< 0.01	< 0.03	< 0.06	< 0.01	< 0.11	--	--
B9404-05	12	2/24/94	8010/8020	--	< 0.01	< 0.03	< 0.06	< 0.01	< 0.11	--	--
B9405-01	4	2/24/94	8010/8020	--	< 0.01	< 0.03	< 0.06	< 0.01	< 0.12	--	--

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mall Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	tert-Butyl benzene	Carbon tetra chloride	Chloro benzene	Chloroethane	Chloroform	Chloro methane	2-Chloro toluene	4-Chloro toluene
B9405-02	6	2/24/94	8010/8020	--	< 0.01	< 0.03	< 0.06	< 0.01	< 0.12	--	--

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mail Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	Dibromo chloro methane	Dibromo chloro propane	1,2-Dibromo ethane	1,2-Dichloro benzene	1,3-Dichloro benzene	1,4-Dichloro benzene	Dichloro difluoro methane	1,1-Dichloro ethane
B-1	5.5	10/22/91	8010/8020	< 0.05	--	< 0.13	< 0.13	< 0.13	< 0.13	--	< 0.05
	8	10/22/91	8021	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	9.5	10/22/91	8010/8020	< 0.05	--	< 0.13	< 0.13	< 0.13	< 0.13	--	< 0.05
	13.5	10/22/91	8010/8020	< 0.05	--	< 0.13	< 0.13	< 0.13	< 0.13	--	< 0.05
B-2	4.5	10/22/91	8010/8020	< 0.05	--	< 0.13	< 0.13	< 0.13	< 0.13	--	< 0.05
	9	10/22/91	8010/8020	< 0.05	--	< 0.13	< 0.13	< 0.13	< 0.13	--	< 0.05
	8.5	10/22/91	8021	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	12.5	10/22/91	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
B-3	4	10/22/91	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
	8	10/22/91	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
	12	10/22/91	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
B-4	5.5	10/22/91	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
	10	10/22/91	8010/8020	< 0.05	--	< 0.13	< 0.13	< 0.13	< 0.13	--	< 0.05
	14	10/22/91	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
B9401-04	10	2/24/94	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
B9401-05	12	2/24/94	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
B9402-02	6	2/24/94	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
B9402-06	14	2/24/94	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
B9403-03	7	2/24/94	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
B9403-04	10	2/24/94	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
B9404-03	8	2/24/94	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
B9404-05	12	2/24/94	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01
B9405-01	4	2/24/94	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mall Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	Dibromo chloro methane	Dibromo chloro propane	1,2-Dibromo ethane	1,2-Dichloro benzene	1,3-Dichloro benzene	1,4-Dichloro benzene	Dichloro difluoro methane	1,1- Dichloro ethane
B9405-02	6	2/24/94	8010/8020	< 0.01	--	< 0.03	< 0.03	< 0.03	< 0.03	--	< 0.01

**Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mail Risk Assessment
Boise, Idaho**

Location	Depth	Sample Date	Test Method	1,2-Dichloro ethane	1,1-Dichloro ethene	cis-1,2-Dichloro ethene	trans-1,2-Dichloro ethene	1,2-Dichloro propane	1,3-Dichloro propane	2,2-Dichloro propane	1,1-Dichloro propene
B-1	5.5	10/22/91	8010/8020	< 0.05	< 0.05	1.30	< 0.05	< 0.05	--	--	--
	8	10/22/91	8021	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	9.5	10/22/91	8010/8020	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	--	--	--
	13.5	10/22/91	8010/8020	< 0.05	< 0.05	< 0.05	< 0.05	< 0.13	--	--	--
B-2	4.5	10/22/91	8010/8020	< 0.05	< 0.05	0.52 J3	< 0.05	< 0.05	--	--	--
	9	10/22/91	8010/8020	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	--	--	--
	8.5	10/22/91	8021	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	12.5	10/22/91	8010/8020	< 0.01	< 0.01	1.40E-02	< 0.01	< 0.01	--	--	--
B-3	4	10/22/91	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
	8	10/22/91	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
	12	10/22/91	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
B-4	5.5	10/22/91	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
	10	10/22/91	8010/8020	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	--	--	--
	14	10/22/91	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
B9401-04	10	2/24/94	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
B9401-05	12	2/24/94	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
B9402-02	6	2/24/94	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
B9402-06	14	2/24/94	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
B9403-03	7	2/24/94	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
B9403-04	10	2/24/94	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
B9404-03	8	2/24/94	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
B9404-05	12	2/24/94	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--
B9405-01	4	2/24/94	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mall Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	1,2-Dichloro ethane	1,1-Dichloro ethene	cis-1,2-Dichloro ethene	trans-1,2-Dichloro ethene	1,2-Dichloro propane	1,3-Dichloro propane	2,2-Dichloro propane	1,1-Dichloro propene
B9405-02	6	2/24/94	8010/8020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	--	--	--

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mall Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	cis-1,3-Dichloro propene	trans-1,3-Dichloro propene	Ethylbenzene	Isopropyl benzene	p-Isopropyl toluene	Methylene bromide	Methylene chloride	n-Propyl benzene
B-1	5.5	10/22/91	8010/8020	< 0.05	< 0.05	< 0.13	--	--	--	< 0.75 U1	--
	8	10/22/91	8021	--	--	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	9.5	10/22/91	8010/8020	< 0.05	< 0.05	< 0.13	--	--	--	< 0.73 U1	--
	13.5	10/22/91	8010/8020	< 0.05	< 0.05	< 0.13	--	--	--	< 0.76 U1	--
B-2	4.5	10/22/91	8010/8020	< 0.05	< 0.05	< 0.13	--	--	--	< 0.63 U1	--
	9	10/22/91	8010/8020	< 0.05	< 0.05	< 0.13	--	--	--	< 0.65 U1	--
	8.5	10/22/91	8021	--	--	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	12.5	10/22/91	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.20 U1	--
B-3	4	10/22/91	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.22 U1	--
	8	10/22/91	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.32 U1	--
	12	10/22/91	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.16 U1	--
B-4	5.5	10/22/91	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.23 U1	--
	10	10/22/91	8010/8020	< 0.05	< 0.05	< 0.13	--	--	--	< 1.10 U1	--
	14	10/22/91	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.15 U1	--
B9401-04	10	2/24/94	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.10	--
B9401-05	12	2/24/94	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.10	--
B9402-02	6	2/24/94	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.12	--
B9402-06	14	2/24/94	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.10	--
B9403-03	7	2/24/94	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.11	--
B9403-04	10	2/24/94	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.11	--
B9404-03	8	2/24/94	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.11	--
B9404-05	12	2/24/94	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.11	--
B9405-01	4	2/24/94	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.12	--

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mall Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	cis-1,3-Dichloro propene	trans-1,3-Dichloro propene	Ethylbenzene	Isopropyl benzene	p-Isopropyl toluene	Methylene bromide	Methylene chloride	n-Propyl benzene
89405-02	6	2/24/94	8010/8020	< 0.01	< 0.01	< 0.03	--	--	--	< 0.12	--

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mall Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	Styrene	1,1,1,2-Tetrachloro ethane	1,1,2,2-Tetrachloro ethane	Tetrachloro ethylene	Toluene	1,2,3-Trichloro benzene	1,1,1-Trichloro ethane	1,1,2-Trichloro ethane
B-1	5.5	10/22/91	8010/8020	--	--	< 0.05	26000.00	< 0.13	--	< 0.05	< 0.05
	8	10/22/91	8021	< 5.00	< 5.00	< 5.00	3090.00	< 5.00	< 5.00	< 5.00	< 5.00
	9.5	10/22/91	8010/8020	--	--	< 0.05	3100.00	< 0.13	--	< 0.05	< 0.05
	13.5	10/22/91	8010/8020	--	--	< 0.05	1100.00 J3	< 0.13	--	< 0.05	< 0.05
B-2	4.5	10/22/91	8010/8020	--	--	< 0.05	3300.00 J3	< 0.13	--	< 0.05	< 0.05
	9	10/22/91	8010/8020	--	--	< 0.05	840.00 J3	< 0.13	--	< 0.05	< 0.05
	8.5	10/22/91	8021	< 5.00	< 5.00	< 5.00	3100.00	< 5.00	< 5.00	< 5.00	< 5.00
	12.5	10/22/91	8010/8020	--	--	< 0.01	4.00	< 0.03	--	< 0.01	< 0.01
B-3	4	10/22/91	8010/8020	--	--	< 0.01	0.23	< 0.03	--	< 0.01	< 0.01
	8	10/22/91	8010/8020	--	--	< 0.01	0.68	< 0.03	--	1.60E-02	< 0.01
	12	10/22/91	8010/8020	--	--	< 0.01	1.40E-02	< 0.03	--	< 0.01	< 0.01
B-4	5.5	10/22/91	8010/8020	--	--	< 0.01	0.05	< 0.03	--	< 0.01	< 0.01
	10	10/22/91	8010/8020	--	--	< 0.05	0.86	< 0.13	--	< 0.05	< 0.05
	14	10/22/91	8010/8020	--	--	< 0.01	0.21	< 0.03	--	< 0.01	< 0.01
B9401-04	10	2/24/94	8010/8020	--	--	< 0.01	< 0.01	< 0.03	--	< 0.01	< 0.01
B9401-05	12	2/24/94	8010/8020	--	--	< 0.01	< 0.01	< 0.03	--	< 0.01	< 0.01
B9402-02	6	2/24/94	8010/8020	--	--	< 0.01	< 0.01	< 0.03	--	< 0.01	< 0.01
B9402-06	14	2/24/94	8010/8020	--	--	< 0.01	< 0.01	< 0.03	--	< 0.01	< 0.01
B9403-03	7	2/24/94	8010/8020	--	--	< 0.01	< 0.01	< 0.03	--	< 0.01	< 0.01
B9403-04	10	2/24/94	8010/8020	--	--	< 0.01	< 0.01	< 0.03	--	< 0.01	< 0.01
B9404-03	8	2/24/94	8010/8020	--	--	< 0.01	< 0.01	< 0.03	--	< 0.01	< 0.01
B9404-05	12	2/24/94	8010/8020	--	--	< 0.01	< 0.01	< 0.03	--	< 0.01	< 0.01
B9405-01	4	2/24/94	8010/8020	--	--	< 0.01	0.11	< 0.03	--	< 0.01	< 0.01

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mail Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	Styrene	1,1,1,2-Tetrachloro ethane	1,1,2,2-Tetrachloro ethane	Tetrachloro ethylene	Toluene	1,2,3-Trichloro benzene	1,1,1-Trichloro ethane	1,1,2-Trichloro ethane
B9405-02	6	2/24/94	8010/8020	--	--	< 0.01	8.80E-02	< 0.03	--	< 0.01	< 0.01

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mail Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	Trichloro ethene	Trichloro fluoro methane	1,2,3-Trichloro propane	1,2,4-Trimethyl benzene	1,3,5-Trimethyl benzene	Vinyl chloride	Xylenes (total)
B-1	5.5	10/22/91	8010/8020	3.10	< 0.13	--	--	--	< 0.25	< 0.13
	8	10/22/91	8021	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	9.5	10/22/91	8010/8020	0.40	< 0.13	--	--	--	< 0.25	< 0.13
	13.5	10/22/91	8010/8020	< 0.05	< 0.13	--	--	--	< 0.25	< 0.13
B-2	4.5	10/22/91	8010/8020	1.50 J3	< 0.13	--	--	--	< 0.25	< 0.13
	9	10/22/91	8010/8020	0.51 J3	< 0.13	--	--	--	< 0.25	< 0.13
	8.5	10/22/91	8021	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
	12.5	10/22/91	8010/8020	< 0.01	< 0.03	--	--	--	< 0.05	< 0.03
B-3	4	10/22/91	8010/8020	< 0.01	< 0.03	--	--	--	< 0.05	< 0.03
	8	10/22/91	8010/8020	< 0.01	< 0.03	--	--	--	< 0.05	< 0.03
	12	10/22/91	8010/8020	< 0.01	< 0.03	--	--	--	< 0.05	< 0.03
B-4	5.5	10/22/91	8010/8020	< 0.01	< 0.03	--	--	--	< 0.05	< 0.03
	10	10/22/91	8010/8020	< 0.05	< 0.13	--	--	--	< 0.25	< 0.13
	14	10/22/91	8010/8020	< 0.01	< 0.03	--	--	--	< 0.05	< 0.03
B9401-04	10	2/24/94	8010/8020	< 0.01	< 0.03	--	--	--	< 0.05	< 0.03
B9401-05	12	2/24/94	8010/8020	< 0.01	< 0.03	--	--	--	< 0.05	< 0.03
B9402-02	6	2/24/94	8010/8020	< 0.01	< 0.03	--	--	--	< 0.06	< 0.03
B9402-06	14	2/24/94	8010/8020	< 0.01	< 0.03	--	--	--	< 0.05	< 0.03
B9403-03	7	2/24/94	8010/8020	< 0.01	< 0.03	--	--	--	< 0.06	< 0.03
B9403-04	10	2/24/94	8010/8020	< 0.01	< 0.03	--	--	--	< 0.05	< 0.03
B9404-03	8	2/24/94	8010/8020	< 0.01	< 0.03	--	--	--	< 0.06	< 0.03
B9404-05	12	2/24/94	8010/8020	< 0.01	< 0.03	--	--	--	< 0.06	< 0.03
B9405-01	4	2/24/94	8010/8020	< 0.01	< 0.03	--	--	--	< 0.06	< 0.03

Results of Chemical Analyses for Volatile Organic Compounds in Soil
VW&R Mall Risk Assessment
Boise, Idaho

Location	Depth	Sample Date	Test Method	Trichloro ethene	Trichloro fluoro methane	1,2,3-Trichloro propane	1,2,4-Trimethyl benzene	1,3,5-Trimethyl benzene	Vinyl chloride	Xylenes (total)
89405-02	6	2/24/94	8010/8020	< 0.01	< 0.03	--	--	--	< 0.06	< 0.03

APPENDIX B
SOIL GAS REPORT

**SOIL GAS SURVEY
OF
BOISE TOWNE SQUARE MALL**

Submitted to

Harding Lawson Associates
7655 Redwood Blvd.
Novato, CA 94948

Submitted by

Hydro Geo Chem, Inc.
1430 North Sixth Avenue
Tucson, Arizona 85705

November 25, 1992

HYDRO GEO CHEM, INC.
SOIL GAS DOCUMENT REVIEW SHEET

Project Code: 51900

Project Name: Boise Towne Square Mall

Title: Soil Gas Survey of Boise Towne Square Mall

Date: November 25, 1992

Report Prepared By: Patricia A. Schumann Date: 12/9/92
for Patrick J. Coughlin, Chemist
Hydro Geo Chem, Inc.

Analytical Results Reviewed By: Patricia A. Schumann Date: 12/9/92
Patricia A. Schumann
Soil Gas Manager

HGC Approval: Mark W. Kuhn Date: 12/9/92
Vice President

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INTRODUCTION

This report presents the methods and results of a soil gas investigation for volatile organic compounds performed November 18-20, 1992 at the Towne Square Mall in Boise, Idaho. The investigation was conducted by Hydro Geo Chem, Inc. under contract to Harding Lawson Associates. The soil gas investigation was designed to evaluate the near surface distribution of total hydrocarbons, selected aromatic and chlorinated hydrocarbons on the site.

BACKGROUND & THEORY

Soil gas surveys consist of the sampling and analysis of the soil gases that reside in the pore space of the unsaturated zone above the water table. Because many common organic compounds and industrial solvents exhibit significant vapor pressures and are relatively insoluble in water, their introduction into subsurface soils results in vapor phase permeation and transport. Should these chemicals reach the water table and travel with the groundwater, vapors will continue to emanate from the contaminated groundwater into overlying soil. Thus organic contamination of the subsurface and, possibly, of groundwater can be detected by measuring the concentration of volatile organics in the soil gas.

The concentration of a volatile organic compound (VOC) in soil gas is a complex function of the distribution of the organic compound and its interaction with the soil. This interaction depends on a number of soil parameters including soil

mineralogy, the soil's natural and anthropogenic organic content, soil moisture, temperature, lithology, and heterogeneity.

Whatever the source of the VOC in soil gas, its concentration is representative of soils contamination at the point of measurement. Volatile organic contaminants are present in the gas phase in unsaturated pore spaces, in the water contained in the unsaturated soils, and sorbed on the soil particles. The total soils concentration is the sum of the VOCs contained in the three phases. The partitioning of the VOC between gas, liquid and solid phases is dependent on both the soil properties and the chemical properties of the organic compound. Thus, given the chemical properties of the VOC and measurements or reasonable estimates of relevant soil parameters, soil-gas data can be used to provide semi-quantitative estimates of soil contamination.

Since equilibrium between phases is generally rapid compared to the rate of gaseous diffusion, soil gas concentrations can be used to estimate the total soil concentration. The major uncertainties in estimating soil concentration from soil gas concentration data are the organic and moisture content of the soils. Chemical properties of particular organic compounds are well known, (i.e., vapor pressure, solubility), and the other relevant soil parameters (i.e., bulk density, porosity) have relatively little effect on soil concentration estimates. The following equation relates soil gas concentrations to total soil concentrations.

$$\frac{C_g}{C_T} = \left[\frac{K_D \rho_b}{H_D} + \frac{\theta_w}{H_D} + (\theta_T - \theta_w) \right]^{-1}$$

Where C_g is the concentration in the gas [M/V air]

C_T is the concentration in the soil [M/V bulk volume soil]

K_D is the water-solid distribution coefficient [M/M solid/M/V water]

ρ_b is the bulk soil density [M/V solid]

H_D is the gas-water distribution coefficient [M/V air/M/V water]

θ_w is the water filled porosity

θ_T is the total porosity

The gas-water distribution coefficient (dimensionless Henry's law constant) is

$$H_D = C_g/C_w = H/RT \approx \rho_g/S$$

where ρ_g is the saturated vapor density [M/V]

and S is the solubility [M/V].

H is the Henry's coefficient

R is the gas constant

T is the temperature in degrees Kelvin

The water-solid distribution coefficient is approximately

$$K_D = \frac{C_s}{C_w} \approx \frac{K_{oc} \cdot \%OC}{100}$$

where C_s is the concentration in the solid (mg/gm)
 C_w is the concentration in the water (mg/ml)
 K_{OC} is the water-organic carbon distribution coefficient
%OC is the percent organic carbon in the soil

Use of soil gas to infer concentrations of sources at distance (such as groundwater plumes) is necessarily much more qualitative. Soil gas data used in this manner are limited by the lack of information regarding the soil parameters interposed between the source and sampling point. It is therefore generally not possible to make quantitative estimates of groundwater concentrations from soil gas samples collected at distance from the saturated interface. Away from source areas (i.e., underground storage tanks, surface spills, etc.) where only the groundwater is providing a significant soil gas concentration, soil gas is often an excellent relative indicator of groundwater contamination. The effectiveness of soil gas surveys to delineate groundwater contamination, is, however, dependent on the depth to groundwater, contaminant concentration in the groundwater, distribution of air permeabilities in the unsaturated zone, and attenuation of the volatile organic by biodegradation or adsorption.

SCOPE OF WORK

Soil gas samples were collected from 31 locations on the investigation site. Sampling locations were determined by an HLA on-site representative.

The volatile organic compounds that were analyzed at each of the sampling locations included the chlorinated hydrocarbons:

Tetrachloroethene (PCE)

Trichloroethene (TCE)

trans 1,2-Dichloroethene

cis 1,2-Dichloroethene

Chloroethene (Vinyl Chloride)

the suite of aromatic compounds known as BTEX:

Benzene

Ethylbenzene

Toluene

Meta + Para Xylenes

Ortho Xylene

and

Total hydrocarbons

METHODS AND INSTRUMENTATION

Sampling probes consisted of 1 3/8" OD, nickel-plated EW drill rod tipped by a loosely held hardened-steel disposable point. A probe was driven into the ground at each sampling location to a depths of 5.0 to 8.0 feet below land surface using a truck-mounted hydraulically-actuated drive point rig. The probe was then pulled up 6 inches to expose the

sampling interval. A regulated vacuum pump was attached to the probe via a stainless steel adaptor. Three to five times the dead volume of the sampling train was purged to ensure that a representative soil gas sample would be collected. The samples were collected by withdrawing the soil gas from the probe using a Hydro Geo Chem designed, computerized mass-flow controller to regulate flow and measure volume sampled. The volatile organics were trapped and concentrated in a glass cartridge contained in a stainless steel housing. The concentrating cartridge was packed with three activated carbons, Carbotrap, Carbopak-B, and Carbosieve S-III, selected to quantitatively trap organics with widely different volatilities. After sampling, the cartridges were brought to the on-site mobile laboratory for analysis.

Gas chromatographic techniques were used to identify and measure concentrations of the various compounds. The soil gas cartridges were desorbed at a temperature of 380 °C using a thermal desorption unit. Samples were injected by the desorber into a gas chromatograph equipped with a megabore capillary column and a photoionization (PID) and Hall conductivity detector. A split from the thermal desorber was sent to an additional column and a flame ionization detector (FID) for analysis of total hydrocarbons (including non-priority pollutant volatile organic compounds). Total hydrocarbons were calibrated using the sum of the halogenated and aromatic hydrocarbons. Actual total hydrocarbon measurements are therefore dependent on the relative distribution of hydrocarbon compounds and their associated FID response.

The make and model of the equipment used to perform these on-site analyses included:

Envirochem 850 Thermal Tube Desorber

Varian 3400 Gas Chromatograph

Tracor 700A Hall Detector

Tracor 703 PID Detector

Varian Flame Ionization (FID) Detector

DB 624, 30m Megabore column, J.W. Scientific

DB 1, 30m Megabore column, J.W. Scientific

Spectra Physics 4400 Chrom Jet Integrator

QUALITY ASSURANCE/QUALITY CONTROL

Quality control and quality assurance were achieved through strict experimental protocol. Chain of custody procedures were observed. All parts of the collection system that come in contact with a sample were cleaned before each use. A system's blank and three calibration runs were performed at the beginning of each day; additional calibrations were performed after every 10 samples.

Standards were prepared from stock mixtures of neat reagent-grade compounds prepared by weighing each compound addition to the mixture and weighing an aliquot volume of the final mixture to establish density (weight/volume). For preparation of daily standards, a measured volume of the standard mixture was injected into a nitrogen-filled

1-liter glass gas bottle through a septum side port. A measured volume of the resulting gas mixture was then injected into a 60-ml/min helium stream feeding a glass, carbon-packed concentrating cartridge. After two minutes the cartridge was transferred to the thermal desorber and analyzed exactly as the soil-gas samples.

Prior to each day's sampling, atmospheric field blanks of the entire sampling apparatus were taken and analyzed to check background contamination in the sampling system and cartridges. In addition, serial duplicates from 10% of the sample locations were analyzed as a measure of reproducibility.

Detection limits were 0.01 micrograms or less per liter of soil gas for all compounds analyzed. Analyses are reported to two significant figures; the minimum amount reported is 0.01 micrograms/liter. In some of the analyses, high levels of a compound may have interfered with and prevented detection of a compound present at a very low level and possessing a similar chromatographic retention time.

RESULTS

Table 1 presents the measured soil gas concentrations from each sampling location. Concentrations, reported in micrograms per liter ($\mu\text{g/l}$) of soil gas. Conversion of soil gas concentrations from $\mu\text{g/l}$ (gas) to ppmV can be achieved by the following equation.

$$C_{\text{ppmV}} = C_{\mu\text{g/l}} \times RT/M_w P$$

where C_{ppmV} = soil gas concentration in ppmV
 $C_{\mu\text{g/l}}$ = soil gas concentration in $\mu\text{g/l}$ (gas)
 R = 0.08205 L-Atm/deg-mole
 T = °K
 M_w = molecular wgt in grams
 P = pressure in atmospheres

If one assumes that a volatile organic compound has a molecular weight of 100 grams/mole, a typical value, C_{ppmV} would be approximately 0.25 $C_{\mu\text{g/l}}$.

Table 1
Summary of Analytical Results
Boise Towne Mall
Boise, Idaho
Concentrations reported in ug/L

Sample ID:	BMO-SG-01	BMO-SG-02	BMO-SG-03A	BMO-SG-03B	BMO-SG-04A	BMO-SG-04B	BMO-SG-05	BMO-SG-06	BMO-SG-07A	BMO-SG-07B
Sample Volume (ml)	100	50	100	50	100	50	200	50	100	50
Vinyl Chloride	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
1,2-TDCE	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
1,2-CDCE	nd	nd	2.8	2.8	nd	nd	nd	20	nd	nd
TCE	nd	0.43	40	41	7.5	nd	nd	74	nd	nd
PCE	2.0	5.7	*1100	1500	*530	1260	6.42	1460	240	290
Benzene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Toluene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Ethyl Benzene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
m & p-Xylenes	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
o-Xylene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
TVOC	6.7	14.9	400	500	350	370	2.96	539	73	72
%R (surrogate)	94	N/A	117	145	N/A	139	85	112	108	111

*offscale

nd indicates less than the detection limit of 0.01Ug/l.

Table 1
Summary of Analytical Results
Boise Towne Mall
Boise, Idaho
Concentrations reported in ug/L

Sample ID:	BMO-SG-08	BMO-SG-09	BMO-SG-10	BMO-SG-11	BMO-SG-12	BMO-SG-13	BMO-SG-14	BMO-SG-15	BMO-SG-16	BMO-SG-17
Sample Volume (ml)	50	200	200	100	100	100	100	100	100	100
Vinyl Chloride	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
1,2-TDCE	nd	0.87	nd	nd	nd	nd	nd	nd	nd	nd
1,2-CDCE	11	13	nd	nd	nd	nd	nd	nd	nd	nd
TCE	6.2	13	8.1	nd	nd	nd	0.93	nd	0.46	0.42
PCE	310	94	105	130	40	61	280	34	260	140
Benzene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Toluene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Ethyl Benzene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
m & p-Xylenes	nd	nd	nd	nd	0.86	nd	nd	nd	nd	nd
o-Xylene	nd	nd	nd	nd	0.39	nd	nd	nd	nd	nd
TVOC	100	57	43	50	8.0	18	115	11	112	48
%R (surrogate)	109	104	98	94	83	88	86	85	105	96

*offscale

nd indicates less than the detection limit of 0.01Ug/l.

Table 1
Summary of Analytical Results
Boise Towne Mall
Boise, Idaho
Concentrations reported in ug/L

Sample ID:	BMO-SG-18	BMO-SG-19A	BMO-SG-19B	BMO-SG-20	BMO-SG-21A	BMO-SG-21B	BMO-SG-22	BMO-SG-23	BMO-SG-24
Sample Volume (ml)	100	100	50	200	200	100	200	200	200
Vinyl Chloride	nd	nd	nd	nd	nd	nd	nd	nd	nd
1,2-TDCE	nd	nd	nd	nd	0.02	nd	0.02	nd	nd
1,2-CDCE	nd	nd	nd	nd	nd	nd	nd	nd	nd
TCE	nd	0.45	0.39	0.28	1.02	0.77	0.30	nd	0.04
PCE	1.5	140	150	1.6	140*	160	12	12	17
Benzene	nd	nd	nd	nd	nd	nd	0.04	nd	nd
Toluene	nd	nd	nd	nd	0.04	nd	0.10	nd	nd
Ethyl Benzene	nd	nd	nd	nd	nd	nd	0.05	nd	nd
m & p-Xylenes	nd	nd	nd	nd	0.07	nd	0.18	nd	nd
o-Xylene	nd	nd	nd	nd	nd	nd	0.06	nd	nd
TVOC	3.6	47	47	24	60	64	22	3.5	4.9
%R (surrogate)	97	103	102	81	116	72	120	111	111

*offscale

nd indicates less than the detection limit of 0.01Ug/l.

Table 1
Summary of Analytical Results
Boise Towne Mall
Boise, Idaho
Concentrations reported in ug/L

Sample ID:	BMO-SG-25A	BMO-SG-25B	BMO-SG-26	BMO-SG-27	BMO-SG-28	BMO-SG-29	BMO-SG-30	BMO-SG-31	FB-11-NOV	FB-12-NOV
Sample Volume (ml)	200	100	200	200	200	200	200	200	200	200
Vinyl Chloride	nd	nd	nd	nd	nd	nd	nd	0.53	nd	nd
1,2-TDCE	nd	nd	0.03	nd	nd	nd	nd	nd	nd	nd
1,2-CDCE	nd	nd	0.57	nd	nd	nd	nd	nd	nd	nd
TCE	0.55	0.47	0.04	0.05	nd	nd	nd	nd	nd	nd
PCE	84	98	0.16	33	2.2	nd	nd	nd	nd	nd
Benzene	nd	nd	1.0	nd	nd	0.03	0.03	0.03	nd	nd
Toluene	nd	nd	0.09	0.10	0.03	nd	0.11	nd	nd	nd
Ethyl Benzene	nd	nd	0.99	0.04	0.05	nd	0.07	nd	nd	nd
m & p-Xylenes	nd	nd	0.13	0.21	nd	nd	nd	nd	nd	0.19
o-Xylene	nd	nd	nd	0.09	nd	nd	nd	nd	nd	nd
TVOC	29	31	38	11.4	3.1	83	2.72	1.53	0.72	0.25
%R (surrogate)	113	108	N/A	110	104	103	122	89	106	N/A

*offscale

nd indicates less than the detection limit of 0.01Ug/l.

Table 1
Summary of Analytical Results
Boise Towne Mall
Boise, Idaho
Concentrations reported in ug/L

Sample ID:	FB-13-NOV	SYS CHECK	TB-11-NOV	TB-12-NOV	TB-13-NOV
Sample Volume (ml)	200	(200)	(200)	(200)	(200)
Vinyl Chloride	nd	nd	nd	nd	nd
1,2-TDCE	nd	nd	nd	nd	nd
1,2-CDCE	nd	nd	nd	nd	nd
TCE	nd	nd	nd	nd	nd
PCE	nd	1.1	2.0	nd	nd
Benzene	nd	nd	nd	nd	nd
Toluene	nd	nd	nd	nd	nd
Ethyl Benzene	nd	nd	nd	nd	nd
m & p-Xylenes	nd	nd	nd	nd	nd
o-Xylene	nd	nd	nd	nd	nd
TVOC	0.35	0.23	0.17	0.69	0.33
%R (surrogate)	N/A	N/A	N/A	113	N/A

*offscale

nd indicates less than the detection limit of 0.01 Ug/l.

APPENDIX C
RESULTS OF CHEMICAL ANALYSES FOR
VOCs IN SOIL GAS

Results of Chemical Analyses for Volatile Organic Compounds in Soil Gas
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Benzene	cis-1,2-Dichloro ethene	trans-1,2-Dichloro ethene	Ethylbenzene	Tetrachloro ethylene	Toluene	Trichloro ethene	Vinyl chloride
FIELD BLANK										
	9/13/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	9/15/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	9/16/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	9/16/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	11/11/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
	11/13/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
SG-01										
	9/13/91	8021	--	< 0.01	< 0.01	--	2.20	--	0.16	< 0.01
D	9/13/91	8021	--	< 0.01	< 0.01	--	2.40	--	0.12	< 0.01
	11/11/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	< 2.00 U2	< 0.01	< 0.01	< 0.01
SG-02										
	9/13/91	8021	--	< 0.01	< 0.01	--	26.00	--	< 0.01	< 0.01
D	9/13/91	8021	--	< 0.01	< 0.01	--	28.00	--	0.03	< 0.01
	11/11/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	< 5.70 U2	< 0.01	0.43	< 0.01
SG-03										
	9/13/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	11/11/92	8021	< 0.01	2.80	< 0.01	< 0.01	1100.00	< 0.01	40.00	< 0.01
D	11/11/92	8021	< 0.01	2.80 J3	< 0.01	< 0.01	1500.00 J3	< 0.01	41.00 J3	< 0.01
SG-04										
	9/14/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	11/11/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	530.00	< 0.01	7.50	< 0.01
D	11/11/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	1260.00 J3	< 0.01	< 0.01	< 0.01
SG-05										
	9/14/91	8021	--	< 0.01	< 0.01	--	0.14	--	0.04	< 0.01
	11/11/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	< 6.42 U2	< 0.01	< 0.01	< 0.01
SG-06										
	9/14/91	8021	--	< 0.01	< 0.01	--	0.11	--	< 0.01	< 0.01
	11/11/92	8021	< 0.01	20.00	< 0.01	< 0.01	1460.00	< 0.01	74.00	< 0.01
SG-07										
	9/14/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01

Notes:

All concentrations reported in micrograms per liter (ug/L).

< indicates value was not detected at or above stated detection limit.

Dashes (--) indicate that no analysis performed for this entry.

D indicates a duplicate sample.

Qualifiers:

J2: Indicates compound result is qualified as estimated due to noncompliance with duplicate precision criteria.

J3: Indicates compound result is qualified as estimated due to noncompliance with spike recovery criteria.

U2: Indicates compound result is qualified as non-detect due to its occurrence in field or trip blank.

Results of Chemical Analyses for Volatile Organic Compounds in Soil Gas
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Benzene	cis-1,2-Dichloro ethene	trans-1,2-Dichloro ethene	Ethylbenzene	Tetrachloro ethylene	Toluene	Trichloro ethene	Vinyl chloride
SG-07	D 9/14/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	11/11/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	240.00	< 0.01	< 0.01	< 0.01
	D 11/11/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	290.00	< 0.01	< 0.01	< 0.01
SG-08	9/14/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	11/11/92	8021	< 0.01	11.00	< 0.01	< 0.01	310.00	< 0.01	6.20	< 0.01
SG-09	9/14/91	8021	--	0.60	< 0.01	--	350.00	--	9.30	< 0.01
	11/11/92	8021	< 0.01	13.00	0.87	< 0.01	94.00	< 0.01	13.00	< 0.01
SG-10	9/14/91	8021	--	74.00	2.20	250.00	1400.00	--	70.00	5.80
	11/11/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	105.00	< 0.01	8.10	< 0.01
SG-11	9/14/91	8021	--	57.00	0.71	140.00	1100.00	--	38.00	3.30
	11/11/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	130.00	< 0.01	< 0.01	< 0.01
SG-12	9/14/91	8021	--	120.00	< 0.01	730.00	4600.00	--	1800.00	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	40.00	< 0.01	< 0.01	< 0.01
SG-13	9/15/91	8021	--	17.00 J2	< 0.01	--	1300.00 J2	--	57.00 J2	< 0.01
	D 9/15/91	8021	--	< 0.01	< 0.01	--	400.00 J2	--	6.20 J2	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	61.00	< 0.01	< 0.01	< 0.01
SG-14	9/15/91	8021	--	290.00	< 0.01	630.00	5500.00	--	170.00	< 0.01
	D 9/15/91	8021	--	380.00	< 0.01	1200.00	5300.00	--	150.00	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	280.00	< 0.01	0.93	< 0.01
SG-15	9/15/91	8021	--	540.00	< 0.01	830.00	5500.00	--	380.00	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	34.00	< 0.01	< 0.01	< 0.01
SG-16	9/15/91	8021	--	< 0.01	< 0.01	2.00	900.00	--	11.00	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	260.00	< 0.01	0.46	< 0.01
SG-17	9/15/91	8021	--	< 0.01	< 0.01	2.00	< 0.01	--	< 0.01	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	140.00	< 0.01	0.42	< 0.01
SG-18	9/15/91	8021	--	< 0.01	< 0.01	2.00	8.00	--	< 0.01	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	1.50	< 0.01	< 0.01	< 0.01

Results of Chemical Analyses for Volatile Organic Compounds in Soil Gas
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Benzene	cis-1,2-Dichloro ethene	trans-1,2-Dichloro ethene	Ethylbenzene	Tetrachloro ethylene	Toluene	Trichloro ethene	Vinyl chloride
SG-19	9/15/91	8021	--	18.00	< 0.01	2.00	290.00	--	< 0.01	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	140.00	< 0.01	0.45	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	150.00	< 0.01	0.39	< 0.01
SG-20	9/15/91	8021	--	400.00	< 0.01	640.00	5100.00	--	460.00	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	1.60	< 0.01	0.28	< 0.01
SG-21	9/15/91	8021	--	< 0.01	< 0.01	--	620.00	--	14.00	< 0.01
	11/13/92	8021	< 0.01	< 0.01	0.02	< 0.01	140.00	0.04	1.02	< 0.01
	11/13/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	160.00	< 0.01	0.77	< 0.01
SG-22	9/16/91	8021	--	< 0.01	< 0.01	--	420.00	--	9.10	< 0.01
	9/16/91	8021	--	< 0.01	< 0.01	--	350.00	--	< 0.01	< 0.01
	11/13/92	8021	0.04	< 0.01	0.02	0.05	12.00	0.10	0.30	< 0.01
SG-23	9/16/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	11/13/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	12.00	< 0.01	< 0.01	< 0.01
SG-24	9/16/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	11/13/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	17.00	< 0.01	0.04	< 0.01
SG-25	9/16/91	8021	--	12.00	< 0.01	--	1100.00	--	17.00	< 0.01
	9/16/91	8021	--	9.40	< 0.01	--	1000.00	--	18.00	< 0.01
	11/13/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	84.00	< 0.01	0.55	< 0.01
	11/13/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	98.00	< 0.01	0.47	< 0.01
SG-26	9/16/91	8021	--	< 0.01	< 0.01	--	230.00	--	11.00	< 0.01
	11/13/92	8021	1.00	0.57	0.03	0.99	0.16	0.09	0.04	< 0.01
SG-27	9/16/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	11/13/92	8021	< 0.01	< 0.01	< 0.01	0.04	33.00	0.10	0.05	< 0.01
SG-28	9/16/91	8021	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01
	11/13/92	8021	< 0.01	< 0.01	< 0.01	0.05	2.20	0.03	< 0.01	< 0.01
SG-29	9/16/91	8021	--	< 0.01	< 0.01	--	940.00	--	62.00	< 0.01
	11/13/92	8021	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Results of Chemical Analyses for Volatile Organic Compounds in Soil Gas
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Benzene	cis-1,2-Dichloro ethene	trans-1,2-Dichloro ethene	Ethylbenzene	Tetrachloro ethylene	Toluene	Trichloro ethene	Vinyl chloride
SG-30	9/16/91	8021	--	< 0.01	< 0.01	--	710.00	--	< 0.01	< 0.01
	11/13/92	8021	0.03	< 0.01	< 0.01	0.07	< 0.01	0.11	< 0.01	< 0.01
SG-31	9/16/91	8021	--	< 0.01	< 0.01	--	640.00	--	< 0.01	< 0.01
	11/13/92	8021	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.53
SG-32 D	9/16/91	8021	--	< 0.01	< 0.01	--	40.00	--	< 0.01	< 0.01
	9/16/91	8021	--	< 0.01	< 0.01	--	32.00	--	< 0.01	< 0.01
SG-33	9/16/91	8021	--	< 0.01	< 0.01	--	2.40	--	< 0.01	< 0.01
SG-34	9/16/91	8021	--	< 0.01	< 0.01	--	660.00	--	18.00	< 0.01
TRIP BLANK	11/11/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	2.00	< 0.01	< 0.01	< 0.01
	11/12/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
	11/13/92	8021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Results of Chemical Analyses for Volatile Organic Compounds in Soil Gas
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Volatile Organic Compounds (total)	ortho-Xylene
FIELD BLANK				
	9/13/91	8021	< 1.00	--
	9/15/91	8021	< 1.00	--
	9/16/91	8021	< 1.00	--
	9/16/91	8021	< 1.00	--
	11/11/92	8021	0.72	< 0.01
	11/12/92	8021	0.25	< 0.01
	11/13/92	8021	0.35	< 0.01
SG-01				
	9/13/91	8021	25.00	--
D	9/13/91	8021	15.00	--
	11/11/92	8021	6.70	< 0.01
SG-02				
	9/13/91	8021	38.00	--
D	9/13/91	8021	42.00	--
	11/11/92	8021	14.90	< 0.01
SG-03				
	9/13/91	8021	23.00	--
	11/11/92	8021	400.00	< 0.01
D	11/11/92	8021	500.00 J3	< 0.01
SG-04				
	9/14/91	8021	9.00	--
	11/11/92	8021	350.00	< 0.01
D	11/11/92	8021	370.00 J3	< 0.01
SG-05				
	9/14/91	8021	22.00	--
	11/11/92	8021	2.96	< 0.01
SG-06				
	9/14/91	8021	13.00	--
	11/11/92	8021	539.00	< 0.01
SG-07				
	9/14/91	8021	10.00	--
D	9/14/91	8021	13.00	--
	11/11/92	8021	73.00	< 0.01
D	11/11/92	8021	72.00	< 0.01
SG-08				
	9/14/91	8021	7.00	--
	11/11/92	8021	100.00	< 0.01
SG-09				
	9/14/91	8021	230.00	--
	11/11/92	8021	57.00	< 0.01

Results of Chemical Analyses for Volatile Organic Compounds in Soil Gas
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Volatile Organic Compounds (total)	ortho-Xylene
SG-10	9/14/91	8021	6200.00	--
	11/11/92	8021	43.00	< 0.01
SG-11	9/14/91	8021	2600.00	--
	11/11/92	8021	50.00	< 0.01
SG-12	9/14/91	8021	55000.00	--
	11/12/92	8021	8.00	0.39
SG-13 D	9/15/91	8021	2500.00 J2	--
	9/15/91	8021	320.00 J2	--
	11/12/92	8021	18.00	< 0.01
SG-14 D	9/15/91	8021	21000.00	--
	9/15/91	8021	20000.00	--
	11/12/92	8021	115.00	< 0.01
SG-15	9/15/91	8021	20000.00	--
	11/12/92	8021	11.00	< 0.01
SG-16	9/15/91	8021	1400.00	--
	11/12/92	8021	112.00	< 0.01
SG-17	9/15/91	8021	60.00	--
	11/12/92	8021	48.00	< 0.01
SG-18	9/15/91	8021	59.00	--
	11/12/92	8021	3.60	< 0.01
SG-19 D	9/15/91	8021	320.00	--
	11/12/92	8021	47.00	< 0.01
	11/12/92	8021	47.00	< 0.01
SG-20	9/15/91	8021	53000.00	--
	11/12/92	8021	24.00	< 0.01
SG-21	9/15/91	8021	500.00	--
	11/13/92	8021	60.00	< 0.01

Results of Chemical Analyses for Volatile Organic Compounds in Soil Gas
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Volatile Organic Compounds (total)	ortho-Xylene
SG-21	D 11/13/92	8021	64.00	< 0.01
SG-22	9/16/91	8021	290.00	--
	D 9/16/91	8021	220.00	--
	11/13/92	8021	22.00	0.06
SG-23	9/16/91	8021	26.00	--
	11/13/92	8021	3.50	< 0.01
SG-24	9/16/91	8021	25.00	--
	11/13/92	8021	4.90	< 0.01
SG-25	9/16/91	8021	1500.00	--
	D 9/16/91	8021	1400.00	--
	11/13/92	8021	29.00	< 0.01
	D 11/13/92	8021	31.00	< 0.01
SG-26	9/16/91	8021	560.00	--
	11/13/92	8021	38.00	< 0.01
SG-27	9/16/91	8021	< 1.00	--
	11/13/92	8021	11.40	< 0.09
SG-28	9/16/91	8021	37.00	--
	11/13/92	8021	3.10	< 0.01
SG-29	9/16/91	8021	1100.00	--
	11/13/92	8021	83.00	< 0.01
SG-30	9/16/91	8021	630.00	--
	11/13/92	8021	2.72	< 0.01
SG-31	9/16/91	8021	610.00	--
	11/13/92	8021	< 1.53 U2	< 0.01
SG-32	9/16/91	8021	42.00	--
	D 9/16/91	8021	36.00	--

Results of Chemical Analyses for Volatile Organic Compounds in Soil Gas
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Volatile Organic Compounds (total)	ortho-Xylene
SG-33	9/16/91	8021	32.00	--
SG-34	9/16/91	8021	600.00	--
TRIP BLANK	11/11/92	8021	0.17	< 0.01
	11/12/92	8021	0.69	< 0.01
	11/13/92	8021	0.69	< 0.01



APPENDIX D

**RESULTS OF CHEMICAL ANALYSES FOR
VOCs IN GROUNDWATER**

Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Benzene	Bromo benzene	Bromochloro methane	Bromo dichloro methane	Bromoform	Bromomethane	n-Butyl benzene	sec-Butyl benzene
BAKER TANK	3/31/94	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
DECON WATER	10/22/91	8021	< 0.50	< 0.50	< 0.50	< 0.20	< 1.00	< 2.00	< 0.50	< 0.50
D	10/22/91	8021	< 0.50	< 0.50	< 0.50	< 0.20	< 1.00	< 2.00	< 0.50	< 0.50
	2/23/93	8010	--	--	--	< 2.00	< 2.00	< 10.00	--	--
EQUIP BLANK	9/12/91	8010	--	--	--	< 1.00	< 1.00	< 5.00	--	--
	2/23/93	8010	--	--	--	< 0.20	< 0.20	< 1.00	--	--
	3/31/93	8012	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
	4/21/93	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
EW-01	3/31/94	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
D	3/31/94	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
EW-01 20' H	2/27/94	8010	--	--	--	< 0.20	< 1.00	< 2.00	--	--
EW-01 40' B	3/01/94	8010	--	--	--	< 10.00	< 50.00	< 100.00	--	--
EW-01 50' H	3/01/94	8010	--	--	--	< 10.00	< 50.00	< 100.00	--	--
EW-01 60' H	3/02/94	8010	--	--	--	< 10.00	< 50.00	< 100.00	--	--
EW-01 70' H	3/02/94	8010	--	--	--	< 10.00	< 50.00	< 100.00	--	--
EW-01 80' B	3/03/94	8010	--	--	--	< 10.00	< 50.00	< 100.00	--	--
EW-01 80' H	3/03/94	8010	--	--	--	< 10.00	< 50.00	< 100.00	--	--
EW-01 90' B	3/03/94	8010	--	--	--	< 10.00	< 50.00	< 100.00	--	--

Notes:

All concentrations reported in micrograms per liter (ug/L).

< indicates value was not detected at or above stated detection limit.

Dashes (--) indicate that no analysis performed for this entry.

D indicates a duplicate sample.

Qualifiers:

J1: Indicates compound result is qualified as estimated due to noncompliance with surrogate recovery criteria.

U2: Indicates compound result is qualified as non-detect due to its occurrence in field or trip blank.

Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Benzene	Bromo benzene	Bromochloro methane	Bromo dichloro methane	Bromoform	Bromomethane	n-Butyl benzene	sec-Butyl benzene
EW-01 90' H	3/03/94	8010	--	--	--	< 10.00	< 50.00	< 100.00	--	--
EW-01 95' H	3/03/94	8010	--	--	--	< 10.00	< 50.00	< 100.00	--	--
GZ-04 D	2/23/93	8010	--	--	--	< 10.00	< 10.00	< 50.00	--	--
	2/23/93	8010	--	--	--	< 10.00	< 10.00	< 50.00	--	--
GZ-06	2/23/93	8010	--	--	--	< 0.20	< 0.20	< 1.00	--	--
MW-01 D	4/21/93	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
	4/21/93	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
MW-01 58' B	3/31/93	8012	< 25.00	--	--	< 10.00	< 10.00	< 50.00	--	--
MW-01 78' B	3/31/93	8012	< 0.50	--	--	< 0.20	--	< 1.00	--	--
MW-02	4/22/93	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
MW-02 58' B	4/15/93	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
MW-02 98' B	4/15/93	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
STATE - MW-01	9/12/91	8010	--	--	--	< 50.00	< 50.00	< 100.00	--	--
STATE - MW-02	9/12/91	8010	--	--	--	< 1.00	< 1.00	< 5.00	--	--
TRIP BLANK	9/12/91	8010	--	--	--	< 1.00	< 1.00	< 5.00	--	--
	2/23/93	8010	--	--	--	< 0.20	< 0.20	< 1.00	--	--
	3/31/93	8012	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
	4/16/93	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
	4/21/93	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--
	3/31/94	8010/8020	< 0.50	--	--	< 0.20	< 0.20	< 1.00	--	--

Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	tert-Butyl benzene	Carbon tetra chloride	Chloro benzene	Chloroethane	Chloroform	Chloro methane	2-Chloro toluene	4-Chloro toluene
BAKER TANK	3/31/94	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
DECON WATER	10/22/91	8021	< 0.50	< 0.50	< 0.50	< 1.00	< 0.20	< 0.50	< 0.50	< 0.50
D	10/22/91	8021	< 0.50	< 0.50	< 0.50	< 1.00	< 0.20	< 0.50	< 0.50	< 0.50
	2/23/93	8010	--	< 2.00	< 5.00	< 10.00	< 2.00	< 20.00	--	--
EQUIP BLANK	9/12/91	8010	--	< 0.50	< 2.00	< 5.00	< 0.50	< 5.00	--	--
	2/23/93	8010	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
	3/31/93	8012	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
	4/21/93	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
EW-01	3/31/94	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
D	3/31/94	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
EW-01 20' H	2/27/94	8010	--	< 0.50	< 0.50	< 1.00	< 0.20	< 0.50	--	--
EW-01 40' B	3/01/94	8010	--	< 25.00	< 25.00	< 50.00	< 10.00	< 25.00	--	--
EW-01 50' H	3/01/94	8010	--	< 25.00	< 25.00	< 50.00	< 10.00	< 25.00	--	--
EW-01 60' H	3/02/94	8010	--	< 25.00	< 25.00	< 50.00	< 10.00	< 25.00	--	--
EW-01 70' H	3/02/94	8010	--	< 25.00	< 25.00	< 50.00	< 10.00	< 25.00	--	--
EW-01 80' B	3/03/94	8010	--	< 25.00	< 25.00	< 50.00	< 10.00	< 25.00	--	--
EW-01 80' H	3/03/94	8010	--	< 25.00	< 25.00	< 50.00	< 10.00	< 25.00	--	--
EW-01 90' B	3/03/94	8010	--	< 25.00	< 25.00	< 50.00	< 10.00	< 25.00	--	--
EW-01 90' H	3/03/94	8010	--	< 25.00	< 25.00	< 50.00	< 10.00	< 25.00	--	--
EW-01 95' H	3/03/94	8010	--	< 25.00	< 25.00	< 50.00	< 10.00	< 25.00	--	--

Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	tert-Butyl benzene	Carbon tetra chloride	Chloro benzene	Chloroethane	Chloroform	Chloro methane	2-Chloro toluene	4-Chloro toluene
GZ-04	2/23/93	8010	--	< 10.00	< 25.00	< 50.00	< 10.00	< 100.00	--	--
D	2/23/93	8010	--	< 10.00	< 25.00	< 50.00	< 10.00	< 100.00	--	--
GZ-06	2/23/93	8010	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
MW-01	4/21/93	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
D	4/21/93	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
MW-01 58' B	3/31/93	8012	--	< 10.00	< 25.00	< 50.00	< 10.00	< 100.00	--	--
MW-01 78' B	3/31/93	8012	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
MW-02	4/22/93	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
MW-02 58' B	4/15/93	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
MW-02 98' B	4/15/93	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
STATE - MW-01	9/12/91	8010	--	< 50.00	< 50.00	< 100.00	< 50.00	< 100.00	--	--
STATE - MW-02	9/12/91	8010	--	< 0.50	< 2.00	< 5.00	< 0.50	< 5.00	--	--
TRIP BLANK	9/12/91	8010	--	< 0.50	< 2.00	< 5.00	< 0.50	< 5.00	--	--
	2/23/93	8010	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
	3/31/93	8012	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
	4/16/93	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
	4/21/93	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--
	3/31/94	8010/8020	--	< 0.20	< 0.50	< 1.00	< 0.20	< 2.00	--	--

**Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
VW&R Mall Risk Assessment
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Location	Sample Date	Test Method	Dibromo chloro methane	Dibromo chloro propane	1,2-Dibromo ethane	1,2-Dichloro benzene	1,3-Dichloro benzene	1,4-Dichloro benzene	Dichloro difluoro methane	1,1-Dichloro ethane
BAKER TANK	3/31/94	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
DECON WATER	10/22/91	8021	< 0.50	< 5.00	< 1.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
D	10/22/91	8021	< 0.50	< 5.00	< 1.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
	2/23/93	8010	< 2.00	--	< 5.00	< 5.00	< 5.00	< 5.00	--	< 2.00
EQUIP BLANK	9/12/91	8010	< 1.00	--	< 1.00	--	--	--	--	< 0.50
	2/23/93	8010	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
	3/31/93	8012	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
	4/21/93	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
EW-01	3/31/94	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
D	3/31/94	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
EW-01 20' H	2/27/94	8010	< 0.50	--	< 1.50	< 0.50	--	< 0.50	< 0.50	< 0.50
EW-01 40' B	3/01/94	8010	< 25.00	--	< 75.00	< 25.00	--	< 25.00	< 25.00	< 25.00
EW-01 50' H	3/01/94	8010	< 25.00	--	< 75.00	< 25.00	--	< 25.00	< 25.00	< 25.00
EW-01 60' H	3/02/94	8010	< 25.00	--	< 75.00	< 25.00	--	< 25.00	< 25.00	< 25.00
EW-01 70' H	3/02/94	8010	< 25.00	--	< 75.00	< 25.00	--	< 25.00	< 25.00	< 25.00
EW-01 80' B	3/03/94	8010	< 25.00	--	< 75.00	< 25.00	--	< 25.00	< 25.00	< 25.00
EW-01 80' H	3/03/94	8010	< 25.00	--	< 75.00	< 25.00	--	< 25.00	< 25.00	< 25.00
EW-01 90' B	3/03/94	8010	< 25.00	--	< 75.00	< 25.00	--	< 25.00	< 25.00	< 25.00
EW-01 90' H	3/03/94	8010	< 25.00	--	< 75.00	< 25.00	--	< 25.00	< 25.00	< 25.00
EW-01 95' H	3/03/94	8010	< 25.00	--	< 75.00	< 25.00	--	< 25.00	< 25.00	< 25.00

Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
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Location	Sample Date	Test Method	Dibromo chloro methane	Dibromo chloro propane	1,2-Dibromo ethane	1,2-Dichloro benzene	1,3-Dichloro benzene	1,4-Dichloro benzene	Dichloro difluoro methane	1,1-Dichloro ethane
GZ-04										
	2/23/93	8010	< 10.00	--	< 25.00	< 25.00	< 25.00	< 25.00	--	< 10.00
D	2/23/93	8010	< 10.00	--	< 25.00	< 25.00	< 25.00	< 25.00	--	< 10.00
GZ-06										
	2/23/93	8010	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
MW-01										
	4/21/93	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
D	4/21/93	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
MW-01 58' B										
	3/31/93	8012	< 10.00	--	< 25.00	< 25.00	< 25.00	< 25.00	--	< 10.00
MW-01 78' B										
	3/31/93	8012	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
MW-02										
	4/22/93	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
MW-02 58' B										
	4/15/93	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
MW-02 98' B										
	4/15/93	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
STATE - MW-01										
	9/12/91	8010	< 50.00	--	< 50.00	--	--	--	--	< 50.00
STATE - MW-02										
	9/12/91	8010	< 1.00	--	< 1.00	--	--	--	--	< 0.50
TRIP BLANK										
	9/12/91	8010	< 1.00	--	< 1.00	--	--	--	--	< 0.50
	2/23/93	8010	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
	3/31/93	8012	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
	4/16/93	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
	4/21/93	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20
	3/31/94	8010/8020	< 0.20	--	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.20

Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
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Location	Sample Date	Test Method	1,2-Dichloro ethane	1,1-Dichloro ethene	1,2-Dichloro ethene	cis-1,2-Dichloro ethene	trans-1,2-Dichloro ethene	1,2-Dichloro propane	1,3-Dichloro propane	2,2-Dichloro propane
BAKER TANK	3/31/94	8010/8020	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
DECON WATER	10/22/91	8021	< 0.50	< 0.50	--	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
D	10/22/91	8021	< 0.50	< 0.50	--	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
	2/23/93	8010	< 2.00	< 2.00	--	< 2.00	< 2.00	< 2.00	--	--
EQUIP BLANK	9/12/91	8010	< 1.00	< 0.50	< 0.50	--	--	< 1.00	--	--
	2/23/93	8010	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
	3/31/93	8012	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
	4/21/93	8010/8020	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
EW-01	3/31/94	8010/8020	< 0.20	< 0.20	--	2.10 J1	< 0.20	< 0.20	--	--
D	3/31/94	8010/8020	< 0.20	< 0.20	--	0.30 J1	< 0.20	< 0.20	--	--
EW-01 20' H	2/27/94	8010	< 0.50	< 0.50	--	< 0.50	< 0.50	< 0.50	--	--
EW-01 40' B	3/01/94	8010	< 25.00	< 25.00	--	< 25.00	< 25.00	< 25.00	--	--
EW-01 50' H	3/01/94	8010	< 25.00	< 25.00	--	< 25.00	< 25.00	< 25.00	--	--
EW-01 60' H	3/02/94	8010	< 25.00	< 25.00	--	< 25.00	< 25.00	< 25.00	--	--
EW-01 70' H	3/02/94	8010	< 25.00	< 25.00	--	< 25.00	< 25.00	< 25.00	--	--
EW-01 80' B	3/03/94	8010	< 25.00	< 25.00	--	< 25.00	< 25.00	< 25.00	--	--
EW-01 80' H	3/03/94	8010	< 25.00	< 25.00	--	< 25.00	< 25.00	< 25.00	--	--
EW-01 90' B	3/03/94	8010	< 25.00	< 25.00	--	< 25.00	< 25.00	< 25.00	--	--
EW-01 90' H	3/03/94	8010	< 25.00	< 25.00	--	< 25.00	< 25.00	< 25.00	--	--
EW-01 95' H	3/03/94	8010	< 25.00	< 25.00	--	< 25.00	< 25.00	< 25.00	--	--

Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
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Location	Sample Date	Test Method	1,2-Dichloro ethane	1,1-Dichloro ethene	1,2-Dichloro ethene	cis-1,2-Dichloro ethene	trans-1,2-Dichloro ethene	1,2-Dichloro propane	1,3-Dichloro propane	2,2-Dichloro propane
GZ-04										
	2/23/93	8010	< 10.00	< 10.00	--	40.00	< 10.00	< 10.00	--	--
D	2/23/93	8010	< 10.00	< 10.00	--	38.00	< 10.00	< 10.00	--	--
GZ-06										
	2/23/93	8010	< 0.20	1.60	--	< 0.20	< 0.20	< 0.20	--	--
MW-01										
	4/21/93	8010/8020	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
D	4/21/93	8010/8020	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
MW-01 58' B										
	3/31/93	8012	< 10.00	< 10.00	--	< 10.00	< 10.00	< 10.00	--	--
MW-01 78' B										
	3/31/93	8012	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
MW-02										
	4/22/93	8010/8020	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
MW-02 58' B										
	4/15/93	8010/8020	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
MW-02 98' B										
	4/15/93	8010/8020	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
STATE - MW-01										
	9/12/91	8010	< 50.00	< 50.00	63.00	--	--	< 50.00	--	--
STATE - MW-02										
	9/12/91	8010	< 1.00	< 0.50	< 0.50	--	--	< 1.00	--	--
TRIP BLANK										
	9/12/91	8010	< 1.00	< 0.50	< 0.50	--	--	< 1.00	--	--
	2/23/93	8010	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
	3/31/93	8012	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
	4/16/93	8010/8020	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
	4/21/93	8010/8020	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
	3/31/94	8010/8020	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	--	--
WASTE H20										
	9/16/91	8021	--	--	--	< 0.10	< 0.10	--	--	--

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Location	Sample Date	Test Method	1,1-Dichloro propene	cis-1,3-Dichloro propene	trans-1,3-Dichloro propene	Ethylbenzene	Isopropyl benzene	p-Isopropyl toluene	Methylene bromide	Methylene chloride
BAKER TANK	3/31/94	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
DECON WATER	10/22/91	8021	< 0.50	--	--	< 0.50	< 0.50	< 0.50	< 4.00	< 0.50
D	10/22/91	8021	< 0.50	--	--	< 0.50	< 0.50	< 0.50	< 4.00	< 0.50
	2/23/93	8010	--	< 2.00	< 2.00	--	--	--	--	< 20.00
EQUIP BLANK	9/12/91	8010	--	< 2.00	< 1.00	--	--	--	--	< 5.00
	2/23/93	8010	--	< 0.20	< 0.20	--	--	--	--	< 2.00
	3/31/93	8012	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
	4/21/93	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
EW-01	3/31/94	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
D	3/31/94	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
EW-01 20' H	2/27/94	8010	--	--	--	--	--	--	--	< 0.50
EW-01 40' B	3/01/94	8010	--	--	--	--	--	--	--	< 25.00
EW-01 50' H	3/01/94	8010	--	--	--	--	--	--	--	< 25.00
EW-01 60' H	3/02/94	8010	--	--	--	--	--	--	--	< 25.00
EW-01 70' H	3/02/94	8010	--	--	--	--	--	--	--	< 25.00
EW-01 80' B	3/03/94	8010	--	--	--	--	--	--	--	< 25.00
EW-01 80' H	3/03/94	8010	--	--	--	--	--	--	--	< 25.00
EW-01 90' B	3/03/94	8010	--	--	--	--	--	--	--	< 25.00
EW-01 90' H	3/03/94	8010	--	--	--	--	--	--	--	< 25.00
EW-01 95' H	3/03/94	8010	--	--	--	--	--	--	--	< 25.00

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Location	Sample Date	Test Method	1,1-Dichloro propene	cis-1,3-Dichloro propene	trans-1,3-Dichloro propene	Ethylbenzene	Isopropyl benzene	p-Isopropyl toluene	Methylene bromide	Methylene chloride
GZ-04										
D	2/23/93	8010	--	< 10.00	< 10.00	--	--	--	--	< 100.00
	2/23/93	8010	--	< 10.00	< 10.00	--	--	--	--	< 100.00
GZ-06										
	2/23/93	8010	--	< 0.20	< 0.20	--	--	--	--	< 2.00
MW-01										
D	4/21/93	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
	4/21/93	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
MW-01 58' B										
	3/31/93	8012	--	< 10.00	< 10.00	< 25.00	--	--	--	< 100.00
MW-01 78' B										
	3/31/93	8012	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
MW-02										
	4/22/93	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
MW-02 58' B										
	4/15/93	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
MW-02 98' B										
	4/15/93	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
STATE - MW-01										
	9/12/91	8010	--	< 60.00	< 50.00	--	--	--	--	< 100.00
STATE - MW-02										
	9/12/91	8010	--	< 2.00	< 1.00	--	--	--	--	< 5.00
TRIP BLANK										
	9/12/91	8010	--	< 2.00	< 1.00	--	--	--	--	< 5.00
	2/23/93	8010	--	< 0.20	< 0.20	--	--	--	--	< 2.00
	3/31/93	8012	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
	4/16/93	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
	4/21/93	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00
	3/31/94	8010/8020	--	< 0.20	< 0.20	< 0.50	--	--	--	< 2.00

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VW&R Mail Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	n-Propyl benzene	Styrene	1,1,1,2-Tetrachloro ethane	1,1,2,2-Tetrachloro ethane	Tetrachloro ethylene	Toluene	1,2,3-Trichloro benzene	1,1,1-Trichloro ethane
BAKER TANK	3/31/94	8010/8020	--	--	--	< 0.20	1800.00	3.00	--	< 0.20
DECON WATER	10/22/91	8021	< 0.50	< 0.50	< 0.50	< 0.50	1610.00	< 0.50	< 0.50	< 0.50
D	10/22/91	8021	< 0.50	< 0.50	< 0.50	< 0.50	2330.00	4.80	< 0.50	< 0.50
	2/23/93	8010	--	--	--	< 2.00	180.00	--	--	< 2.00
EQUIP BLANK	9/12/91	8010	--	--	--	< 5.00	< 0.50	--	--	< 0.50
	2/23/93	8010	--	--	--	< 0.20	< 0.20	--	--	< 0.20
	3/31/93	8012	--	--	--	< 0.20	0.30	0.70	--	2.80
	4/21/93	8010/8020	--	--	--	< 0.20	< 0.20	< 0.50	--	< 0.20
EW-01	3/31/94	8010/8020	--	--	--	< 0.20	20000.00 J1	3.30 J1	--	0.30 J1
D	3/31/94	8010/8020	--	--	--	< 0.20	22000.00 J1	3.30 J1	--	< 0.20
EW-01 20' H	2/27/94	8010	--	--	< 0.50	< 0.50	973.00	< 0.50	--	< 0.50
EW-01 40' B	3/01/94	8010	--	--	< 25.00	< 25.00	20300.00	< 25.00	--	< 25.00
EW-01 50' H	3/01/94	8010	--	--	< 25.00	< 25.00	440.00	< 25.00	--	< 25.00
EW-01 60' H	3/02/94	8010	--	--	< 25.00	< 25.00	140.00	< 25.00	--	< 25.00
EW-01 70' H	3/02/94	8010	--	--	< 25.00	< 25.00	423.00	< 25.00	--	< 25.00
EW-01 80' B	3/03/94	8010	--	--	< 25.00	< 25.00	2220.00	< 25.00	--	< 25.00
EW-01 80' H	3/03/94	8010	--	--	< 25.00	< 25.00	50.30	< 25.00	--	< 25.00
EW-01 90' B	3/03/94	8010	--	--	< 25.00	< 25.00	1550.00	< 25.00	--	< 25.00
EW-01 90' H	3/03/94	8010	--	--	< 25.00	< 25.00	233.00	< 25.00	--	< 25.00
EW-01 95' H	3/03/94	8010	--	--	< 25.00	< 25.00	24.00	< 25.00	--	< 25.00

Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
VW&R Mail Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	n-Propyl benzene	Styrene	1,1,1,2-Tetrachloro ethane	1,1,2,2-Tetrachloro ethane	Tetrachloro ethylene	Toluene	1,2,3-Trichloro benzene	1,1,1-Trichloro ethane
GZ-04										
	2/23/93	8010	--	--	--	< 10.00	3000.00	--	--	< 10.00
D	2/23/93	8010	--	--	--	< 10.00	3100.00	--	--	< 10.00
GZ-06										
	2/23/93	8010	--	--	--	< 0.20	360.00	--	--	0.20
MW-01										
	4/21/93	8010/8020	--	--	--	< 0.20	< 0.20	< 0.50	--	< 0.20
D	4/21/93	8010/8020	--	--	--	< 0.20	< 0.20	< 0.50	--	< 0.20
MW-01 58' B										
	3/31/93	8012	--	--	--	< 10.00	650.00	< 25.00	--	< 10.00
MW-01 78' B										
	3/31/93	8012	--	--	--	< 0.20	< 1.00 U2	< 0.50	--	< 0.20
MW-02										
	4/22/93	8010/8020	--	--	--	< 0.20	< 0.20	< 0.50	--	< 0.20
MW-02 58' B										
	4/15/93	8010/8020	--	--	--	< 0.20	2.10	< 0.50	--	< 0.20
MW-02 98' B										
	4/15/93	8010/8020	--	--	--	< 0.20	< 0.20	< 0.50	--	< 0.20
STATE - MW-01										
	9/12/91	8010	--	--	--	< 50.00	5100.00	--	--	< 50.00
STATE - MW-02										
	9/12/91	8010	--	--	--	< 5.00	6.10	--	--	2.00
TRIP BLANK										
	9/12/91	8010	--	--	--	< 5.00	< 0.50	--	--	< 0.50
	2/23/93	8010	--	--	--	< 0.20	< 0.20	--	--	< 0.20
	3/31/93	8012	--	--	--	< 0.20	< 0.20	0.50	--	< 0.20
	4/16/93	8010/8020	--	--	--	< 0.20	< 0.20	1.00	--	< 0.20
	4/21/93	8010/8020	--	--	--	< 0.20	< 0.20	1.00	--	< 0.20
	3/31/94	8010/8020	--	--	--	< 0.20	< 0.20	< 0.50	--	< 0.20
WASTE H2O										
	9/16/91	8021	--	--	--	--	39.00	--	--	--

**Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
VW&R Mall Risk Assessment
Boise, Idaho**

Location	Sample Date	Test Method	1,1,2-Trichloro ethane	Trichloro ethene	Trichloro fluoro methane	1,2,3-Trichloro propane	1,1,2-Trichloro-1,2,2-tri fluoroethane	1,2,4-Trimethyl benzene	1,3,5-Trimethyl benzene	Vinyl chloride
BAKER TANK	3/31/94	8010/8020	< 0.20	1.60	< 0.50	--	--	--	--	< 1.00
DECON WATER	10/22/91	8021	< 0.50	< 0.50	< 0.50	< 0.50	--	< 0.50	< 0.50	< 0.20
D	10/22/91	8021	< 0.50	0.90	< 0.50	< 0.50	--	< 0.50	< 0.50	< 0.20
	2/23/93	8010	< 2.00	< 2.00	< 5.00	--	--	--	--	< 10.00
EQUIP BLANK	9/12/91	8010	< 2.00	< 0.50	--	--	< 1.00	--	--	< 1.00
	2/23/93	8010	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
	3/31/93	8012	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
	4/21/93	8010/8020	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
EW-01	3/31/94	8010/8020	< 0.20	28.00 J1	< 0.50	--	--	--	--	< 1.00
D	3/31/94	8010/8020	< 0.20	35.00 J1	< 0.50	--	--	--	--	< 1.00
EW-01 20' H	2/27/94	8010	< 0.50	1.60	< 0.50	--	--	--	--	< 0.20
EW-01 40' B	3/01/94	8010	< 25.00	< 25.00	< 25.00	--	--	--	--	< 10.00
EW-01 50' H	3/01/94	8010	< 25.00	< 25.00	< 25.00	--	--	--	--	< 10.00
EW-01 60' H	3/02/94	8010	< 25.00	< 25.00	< 25.00	--	--	--	--	< 10.00
EW-01 70' H	3/02/94	8010	< 25.00	< 25.00	< 25.00	--	--	--	--	< 10.00
EW-01 80' B	3/03/94	8010	< 25.00	< 25.00	< 25.00	--	--	--	--	< 10.00
EW-01 80' H	3/03/94	8010	< 25.00	< 25.00	< 25.00	--	--	--	--	< 10.00
EW-01 90' B	3/03/94	8010	< 25.00	< 25.00	< 25.00	--	--	--	--	< 10.00
EW-01 90' H	3/03/94	8010	< 25.00	< 25.00	< 25.00	--	--	--	--	< 10.00
EW-01 95' H	3/03/94	8010	< 25.00	< 25.00	< 25.00	--	--	--	--	< 10.00

Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	1,1,2-Trichloroethane	Trichloroethene	Trichlorofluoromethane	1,2,3-Trichloropropane	1,1,2-Trichloro-1,2,2-trifluoroethane	1,2,4-Trimethylbenzene	1,3,5-Trimethylbenzene	Vinyl chloride
GZ-04										
	2/23/93	8010	< 10.00	13.00	< 25.00	--	--	--	--	< 50.00
D	2/23/93	8010	< 10.00	11.00	< 25.00	--	--	--	--	< 50.00
GZ-06										
	2/23/93	8010	< 0.20	1.90	< 0.50	--	--	--	--	< 1.00
MW-01										
	4/21/93	8010/8020	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
D	4/21/93	8010/8020	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
MW-01 58' B										
	3/31/93	8012	< 10.00	< 10.00	< 25.00	--	--	--	--	< 50.00
MW-01 78' B										
	3/31/93	8012	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
MW-02										
	4/22/93	8010/8020	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
MW-02 58' B										
	4/15/93	8010/8020	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
MW-02 98' B										
	4/15/93	8010/8020	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
STATE - MW-01										
	9/12/91	8010	< 50.00	70.00	--	--	< 50.00	--	--	< 100.00
STATE - MW-02										
	9/12/91	8010	< 2.00	< 0.50	--	--	< 1.00	--	--	< 1.00
TRIP BLANK										
	9/12/91	8010	< 2.00	< 0.50	--	--	1.20	--	--	< 1.00
	2/23/93	8010	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
	3/31/93	8012	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
	4/16/93	8010/8020	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
	4/21/93	8010/8020	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
	3/31/94	8010/8020	< 0.20	< 0.20	< 0.50	--	--	--	--	< 1.00
WASTE H2O										
	9/16/91	8021	--	< 0.10	--	--	--	--	--	< 0.10

Results of Chemical Analyses for Volatile Organic Compounds in Groundwater
VW&R Mail Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Volatile Organic Compounds (total)	Xylenes (total)
BAKER TANK	3/31/94	8010/8020	--	< 0.50
DECON WATER	10/22/91	8021	--	< 0.50
D	10/22/91	8021	--	0.90
EQUIP BLANK	3/31/93	8012	--	< 0.50
	4/21/93	8010/8020	--	< 0.50
EW-01	3/31/94	8010/8020	--	< 0.50
ID	3/31/94	8010/8020	--	< 0.50
MW-01	4/21/93	8010/8020	--	< 0.50
D	4/21/93	8010/8020	--	< 0.50
MW-01 58' B	3/31/93	8012	--	< 25.00
MW-01 78' B	3/31/93	8012	--	< 0.50
MW-02	4/22/93	8010/8020	--	< 0.50
MW-02 58' B	4/15/93	8010/8020	--	< 0.50
MW-02 98' B	4/15/93	8010/8020	--	< 0.50
TRIP BLANK	3/31/93	8012	--	< 0.50
	4/16/93	8010/8020	--	< 0.50
	4/21/93	8010/8020	--	< 0.50
	3/31/94	8010/8020	--	< 0.50
WASTE H2O	9/16/91	8021	100.00	--

Results of Chemical Analyses for Semivolatile Organic Compounds in Groundwater
VW&R Mall Risk Assessment
Boise, Idaho

Location	Sample Date	Test Method	Hexachloro butadiene	Naphthalene	1,2,4- Trichloro benzene
DECON WATER	10/22/91	8021	< 0.50	< 0.50	< 0.50
D	10/22/91	8021	< 0.50	< 0.50	< 0.50

Notes:

All concentrations reported in micrograms per liter (ug/L).
 < indicates value was not detected at or above stated detection limit.
 Dashes (--) indicate that no analysis performed for this entry.
 D indicates a duplicate sample.

APPENDIX E

**DEPARTMENT AND CITY COMMENTS AND
RESPONSE TO COMMENTS LETTERS**



August 26, 1994

Michael Gaudette
Van Waters & Rogers, Inc.
2723 South Cole Road
Boise, Idaho 83709

Re: Review of Draft Site Investigation Report/Remedial Action Plan (SI/RAP) Boise
Towne Square Mall Boise, Idaho

Dear Mr. Gaudette:

The following remarks or requests for modification represent a compilation of comments by Division of Environmental Quality (DEQ) staff reviewers. Please address the following comments:

- **General comment on Executive Summary and 8.1 Remedial Action Objectives;** Any language used in stating the purpose of the RAP must parallel the language found in paragraph 13.a. through h. of the Boise Mall Order (BMO). We suggest listing those items that the BMO requires the RAP to address.
- **General comment;** The BMO states that the RAP is to provide a proposal for cleanup levels (CLs) not "target remedial goals" (TRGs). Modify the SI/RAP to reflect the language agreed upon in the BMO.
- **General comment;** In several places the SI/RAP provides that the TRGs will be modified once the PSA risk assessment is completed. This is not acceptable. We can agree that the CLs may be modified.
- **General comment;** The BMO provides that the RAP must include a general project schedule. This, apparently, has not been included.
- **Page xii, last sentence** should read: "Vadose zone soil beneath the site has been remediated and is not considered further in this RAP."
- **Page 6, first paragraph, last sentence** should read: "Some samples collected in April, 1989 were analyzed after their holding times had been exceeded at the analytical laboratory resulting in reported values that may have been less than actual concentrations. Those sample locations were re-sampled and analyzed in June, 1989

within the allotted holding times yielding valid results."

- **Page 25, paragraph three;** It appears that a statement comparing "strong" and "weak" seismic reflectors is intended. Clarify the sentence: "A strong reflector may represent a more subtle change in lithology..."
- **Page 35, paragraph two, last sentence** should read: "...therefore, site vadose zone soil is considered to be effectively remediated."
- **Page 35, last paragraph (regarding isoconcentration contours on Plate 2);** The 1,000 $\mu\text{g/l}$ isocon is shown on Plate 2 as a closed loop within the Mall property at the downgradient property boundary with no data points to support this (inferences about ground water concentrations based on soil gas measurements is qualitative at best). Additionally, concentrations of perc fluctuating around 1,000 $\mu\text{g/l}$ have been detected directly downgradient across Milwaukee Avenue near the Westpark treatment system (MW-9). Consequently, the 1,000 $\mu\text{g/l}$ isocon on Plate 2 should be depicted as an open contour at the downgradient Mall property boundary.
- **Page 38, general comment;** The Risk Assessment Summary does not accurately describe the purpose of the RA. As provided by the BMO, the RA is to characterize the "current and potential threats to human health and the environment posed by the presence of Perc Compounds and Aromatic Compounds at the Site, and immediately downgradient from the Site." The language in the SI/RAP must more accurately reflect the language in the BMO.
- **Page 38, third paragraph, second sentence** should read: "...no longer present in vadose zone soil at the site..."
- **Page 39, second paragraph, second sentence** should read: "...chemicals in vadose zone soil are absent;..."
- **Page 43, last paragraph, first sentence** should read: "Vadose zone soil, therefore, is no longer considered to be a source..."
- **Page 46, second paragraph, fourth sentence** should read: "However, all groundwaters of the State are considered a potable supply unless they are specifically designated otherwise."
- **Page 46, paragraph 2, sixth sentence** should read: "The vadose zone soil beneath the area of the former AST has been remediated..."
- **Page 48, last paragraph, last sentence** should read: "Nonetheless, all aquifers of

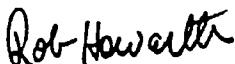
Michael Gaudette
August 26, 1994
Page 4

be determined so that additional sparge wells can be placed such that individual zones of influence will converge at depth.

- **Page 95, second paragraph, first sentence states:** "The air sparging portion of the test will be conducted by injecting air into a well which is screened across the affected zone of the aquifer." Typically, air sparging well screens are very short, usually only one or two feet in length. This is because injected air will exit out of the top of the screen in a vertical well. Consequently, installing a well and screening the entire affected zone of the aquifer would be ineffective for sparging purposes. Additionally, the target injection zone (10 to 30 feet below the water table) will have no affect on contaminants known to exist below this interval. Although the highest contaminant concentration at EW-1 was detected at about 40 feet below land surface, without any hydraulic control, contaminants below this interval will continue to migrate unaffected by the sparge well(s).
- **Page 96, second paragraph, first sentence states:** "For test points completed in the saturated zones, continuous water level measurements will be performed." At what distance from the (air) injection point will these test points be located? The test points should be able to measure any physical and chemical (i.e., dissolved oxygen) changes at the depth the air is being injected. This will help determine the zone of influence of the sparge point at depth.

I would appreciate hearing your response to the items mentioned above. Feel free to contact me at 334-0550 if you have any questions.

Sincerely,



Rob Howarth
Environmental Hydrogeologist

cc: Ron Lane, DEQ/SWIRO
Joy Palmer, DEQ/SWIRO
Michelle Beekman, HLA
Doug Conde, Deputy Attorney General
BMO File

the State are considered a potable supply unless they are designated otherwise (i.e., geothermal waters)."

- **Page 56, third paragraph, first sentence** should read: "...are highly volatile and light non-aqueous phase liquids."
- **Page 64, Section 9.1.2;** Institutional acceptance by the Department will be dependent upon the technical approach of the air sparging alternative.
- **Page 67, last paragraph;** Provide a specific reference to the "literature" used as a basis for stating the expected effectiveness of air sparging at perc-contaminated sites.
- **Page 68, third paragraph;** Based on the latest information from a local project involving the air sparging of perc and the most recent research projects incorporating this technology, the Department would look more favorably on a design which would create a "curtain" effect perpendicular to groundwater flow.
- **Page 81, last paragraph;** It is stated that "The various components of Alternative 2 are well-proven and reliable technologies with few, if any, major unknown factors that could impact implementability." The DEQ will need to review any site specific projects in which VW&R has been involved where perc has been remediated successfully using air sparging technology from 40 feet or greater below ground surface. Some of the unknown factors that are associated with air sparging of chlorinated solvents in deep saturated zones are determining the effects of air channeling, the effective radius of influence of the sparge point at depth and the mounding effect and gradient changes, just to name a few. All of these unknown factors will have to be addressed to the satisfaction of the Department.
- **Page 86;** Any aquifer tests should include an evaluation of water level trends or fluctuations unrelated to controlled pumping stresses (e.g., barometric effects). A workplan describing the details of the proposed aquifer test procedures should be submitted for DEQ review.
- **Page 93, Section 11.2.1;** Although air sparging and vapor extraction has been used throughout Idaho for petroleum contaminated sites, it has not been demonstrated to be effective at any sites in Idaho where dense chlorinated solvents are the contaminants of concern. Air sparging and vapor extraction provide no hydraulic control on the movement of contaminated groundwater, and will not suffice as a stand-alone remedial action.
- **Page 94, Section 11.2.2;** If an individual, vertical sparge well is used for the short duration design test, the effective zone of influence of the sparge well at depth must

IDAHO DEPARTMENT
OF HEALTH AND WELFAREDIVISION OF
ENVIRONMENTAL QUALITY

1445 North Orchard, Suite 100, Statehouse Mall, Boise, ID 83720-9000, (208) 334-0550

Cecil D. Andrus, Governor

October 25, 1994

MALLRAP.094

Mr. Mike Gaudette
Van Waters & Rogers, Inc.
2723 South Cole Road
Boise, Idaho 83709

Post-it Fax Note	7671	Date	10/25/94	Pages	2
To	Mike Gaudette	From	Rob Howarth		
Co/Dept.	VWR	Co.	DEQ-SWIR		
Phone #		Phone #	334-0550		
Fax #	362-6548	Fax #	334-5887		

Re: Response to Mall SI/RAP Comments Dated October 12, 1994

Dear Mr. Gaudette:

The Division of Environmental Quality (DEQ) has reviewed your reply to the first four bullet items of our August 26, 1994 letter on the Mall SI/RAP. It is our understanding that all other bullet items presented in that letter will be addressed according to discussions held during a conference call on September 15, 1994. Our comments based on review of your October 12, 1994 letter are as follows:

1. We agree, in concept, to your responses or proposed changes on items one (language in RAP paralleling language in the BMO) and three (modification of cleanup levels).
2. For item number two, we have no concerns with setting cleanup levels in the RAP that may be revised upon review of the PSA risk assessment. The Boise Mall Order (BMO) provides that the risk assessment is to evaluate "current and potential threats to human health and the environment posed by the presence of Perc Compounds and Aromatic Compounds at the Site, and immediately downgradient from the Site." The BMO further provides that risk assessment issues not resolved in the BMO shall be resolved in the PSA Consent Order. Based upon the risk assessment and any other relevant information, the RAP is to set forth cleanup levels for perc compounds. Under these circumstances, the proposed cleanup levels in the BMO RAP should indeed take into consideration risks presented in the area immediately downgradient from the Mall. In addition, the BMO recognizes the link to the PSA as a whole. Therefore, it is acceptable to propose cleanup levels that may be reevaluated at the time the PSA risk assessment is presented and reviewed by DEQ. We would prefer that the cleanup levels not be labeled "interim." Rather, the RAP should simply explain that these are proposed cleanup levels that may be reevaluated at the time the PSA risk assessment is reviewed by DEQ.

Mike Gaudette
October 25, 1994
Page 2

3. Item number four deals with the issue of a general project schedule for the Mall RAP. However, a Water Supply Order schedule was attached to your letter. Please clarify your response.

Feel free to contact me at (208) 334-0550 if you have any questions concerning this matter.

Sincerely,

Ron Lane for

Rob Howarth
Environmental Hydrogeologist

cc: Chris Smith, HLA
Ron Lane, DEQ/SWIRO
Doug Conde, Deputy Attorney General
BMO File



October 12, 1994

20786 00742

Mr. Ron Lane
Idaho Department of Health and Welfare
Division of Environmental Quality
1445 N. Orchard
Boise, Idaho 83706-2239

Mall SI/RAP
Responses to General Comments

Dear Mr. Lane

On behalf of Van Waters & Rogers Inc. (VW&R), Harding Lawson Associates (HLA) prepared this letter as a follow-up to conversations on the comments from the Idaho Department of Health and Welfare (the Department) dated August 26, 1994, received on the *Draft Site Investigation Report/Remedial Action Plan, Boise Towne Square Mall (SI/RAP)*. Responses to the specific comments, as discussed in our conference call on September 14, 1994, are not provided in this letter. Response to the general comments as discussed on September 16, 1994, are provided below. The final SI/RAP will be submitted to the Department after the responses to the general comments are approved by the Department. The general comments were reproduced here as shown in the Department letter.

General Comment on Executive Summary and 8.1 Remedial Action Objectives: Any language used in stating the purpose of the RAP must parallel the language found in paragraph 13 a. through h. of the Boise Mall Order (BMO). We suggest listing those items that the BMO requires the RAP to address.

Response: Section 8.0 of the RAP will be revised to include the language (items a through h) in the BMO which describes the elements that are to be included in the RAP. All of the elements are addressed and included in the current RAP.

General Comment: The BMO states that the RAP is to provide a proposal for cleanup levels (CLs) not "target remedial goals" (TRGs). Modify the SI/RAP to reflect language agreed upon in the BMO.

Response: VW&R after re-examining the language contained in the BMO with respect to cleanup levels, proposes that interim cleanup levels consisting of proposed or established maximum contaminant levels (MCLs) be established for the chemicals of potential concern in groundwater that were identified in the risk assessment prepared for the Mall. Establishment of final cleanup levels for groundwater at the Mall is, at this time, technically unreasonable without the benefit of considering all pertinent and necessary data. Establishment of MCLs as interim cleanup levels for groundwater at the Mall is overly protective of human health since the Mall risk assessment concluded, and the IDEQ concurred through their approval of the document, that health risks for the two identified complete pathways (i.e.,

October 12, 1994
20786 00742
Mr. Ron Lane
Idaho Department of Health and Welfare
Page 2

inhalation of indoor and outdoor air) are less than the target risk criteria defined in the National Contingency Plan. Consequently, implementation of remedial activities at the Mall was not considered necessary to mitigate volatilization of VOCs from groundwater.

VW&R, however, does recognize that implementation of groundwater remedial activities at the Mall will promote accelerated remediation of groundwater, particularly in downgradient areas (i.e., the Preliminary Study Area [PSA]) where the potential for complete pathways other than those identified at the Mall is greater. The risk assessment currently being prepared for the PSA will identify any completed pathways and receptors in the PSA, evaluate potential health risks to identified receptors due to potential exposures to impacted media, and calculate appropriate cleanup levels for impacted media that are protective of human health. As stated earlier, the PSA risk assessment is currently being prepared and is expected to be completed by the end of 1994, approximately two months earlier than the schedule outlined in the PSA Consent Order requires. VW&R, after evaluating the components of both the Mall and PSA consent orders, recognized that the Mall and PSA are not unique and separate entities both rather are interconnected, and that specific activities completed (or not completed) at the Mall could have a profound impact on the PSA. VW&R therefore concluded it was critical to implement ground remediation activities at the Mall and to complete the PSA risk assessment sooner than required by the order to ensure establishment of cleanup levels that are protective of human health.

Establishment of the groundwater cleanup level for the Mall at this time is therefore not practical or technically reasonable considering the interconnection of the Mall with the PSA. Evaluation of all data having a potential influence on critical decision-making processes should be considered before cleanup levels are established. VW&R, therefore, proposes that only interim cleanup levels be established at the Mall pending the completion of the PSA risk assessment and IDEQ concurs with its content and approves the document. At that time, re-evaluation of the interim cleanup levels would occur to identify if concentrations of the specified chemicals of concern in groundwater other than the proposed or established MCLs is required to be protective of human health. If applicable, VW&R would propose this health-based cleanup level be established for the Mall and would then seek the IDEQ's approval.

General Comment: In several places the SI/RAP provides that the TRGs (interim CLs) will be modified once the PSA risk assessment is completed. This is not acceptable. We can agree that the CLs may be modified.

Response: VW&R did not assume that TRGs would be modified pending the outcome of the PSA risk assessment; however, we were not as clear in this matter as we should have been. Please refer to the last paragraph of VW&R's response to IDEQ's comment related to the establishment of cleanup levels for clarification of this issue.

October 12, 1994
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Mr. Ron Lane
Idaho Department of Health and Welfare
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A proposed process whereby cleanup levels could be modified is presented in that paragraph. Appropriate changes will be made in the SI/RAP.

General Comment: The BMO provides that the RAP must include a general project schedule. This apparently has not been included.

Response: The revised document will include a schedule. A copy of the schedule is included as an attachment to this letter.

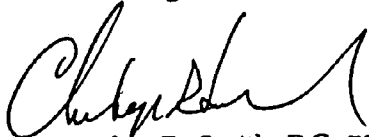
Please call either of the undersigned at (415) 883-0112 or Mike Gaudette of VW&R at (208) 362-6545, if you have any questions or would like to discuss these matters further.

Very truly yours,

HARDING LAWSON ASSOCIATES



Bethany Flynn
Senior Geologist



Christopher R. Smith, P.G. 736
Principal Hydrogeologist

BPF/CRS/JC36837-V

cc: Mike Gaudette
Douglas M. Conde



December 22, 1994

MALLRAP.D94

Mr. Mike Gaudette
Van Waters & Rogers, Inc.
2723 South Cole Road
Boise, Idaho 83709

Re: Mall Site Investigation/Remedial Action Plan (SI/RAP) Public Comments

Dear Mr. Gaudette:

The Division of Environmental Quality (DEQ) has provided a 30-day public comment period for the *Final Draft Site Investigation Report, Remedial Action Plan, Boise Towne Square Mall, Boise, Idaho*. We have also performed an additional internal review of the document. Based upon this review and the public comments, we are withholding final approval of the SI/RAP until the comments are addressed.

The City of Boise was the only party to provide comments during the 30-day review period. Those comments are attached for your consideration. We ask that you respond to each of the City's comments in letter format and also modify the plan in accordance with any of the more significant suggested changes. It may be beneficial to discuss some of the comments in a meeting or a conference call if the significance of an issue is not clear to you.

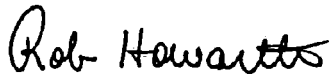
The following comments were developed during DEQ's review of the document. Please respond to these as appropriate.

- **Page ix, second column, first paragraph, Executive Summary;** We have previously reached agreement on language that deals with possible modification of cleanup levels (CLs) based upon consideration of the forthcoming PSA risk assessment. However, this paragraph appears to assert as fact that the CLs will be revised. We request that "These, however, will be modified...." be changed to "These, however, may be modified..."
- **Table 8. Boise Mall Order Schedule;** Paragraph 15 of the Boise Mall Order (BMO) indicates that the RAP is to be revised and resubmitted within 14 days of receipt of the Department's notice that the RAP contains deficiencies. From the proposed schedule, it is not clear whether this is understood. Please confirm that all aspects of the proposed schedule correlate with paragraphs 15 through 17 of the BMO.

Mike Gaudette
December 22, 1994
Page 2

We appreciate your consideration of these comments and look forward to completion of the approval process for the Mall SI/RAP. Feel free to contact me at (208) 334-0550 if you have any questions.

Sincerely,



Rob Howarth
Environmental Hydrogeologist

Enclosure

cc: Ron Lane, DEQ-SWIRO
Doug Conde, Deputy Attorney General
Chris Smith, HLA
BMO File



PUBLIC WORKS DEPARTMENT
CITY HALL
4TH FLOOR

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MAYOR

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CAROLYN TERTELING
COUNCIL PRO TEM

SARA BAKER
ANNE STITES HAUSRATH
M. JEROME MAPP
MIKE WETHERELL

December 9, 1994

Idaho Division of Environmental Quality
1445 N. Orchard
Boise, ID. 83706

ATTN: Rob Howarth

RE: Comments on Final Draft Site Investigation Report....Boise Towne Square Mall....

Rob:

The following comments are offered for your use in completing the remedial action plan for the Boise Towne Square Mall, dated November 2, 1994. Please note that these comments are representative and provide an overview of the City's major concerns.

1. Pages 2-5, Section 2.2: To clarify the ^{multiple} multiply sampling events conducted at the site, it would be helpful to include figures (i.e. plates 3, 4, and 5) and tables immediately following the discussion of each investigation. The figures and tables should show sampling locations, total depths (if appropriate), and analytical results.
2. Page 8, Section 3.3: A stratigraphic column of the geologic units studied in the investigations should be included in this section.
3. Page 9, Section 3.4: Although it is mentioned that potable water at the site is supplied by Boise Water Corporation, it is not mentioned that there is an offsite Boise Water Corporation water supply well that is in the downgradient path of the contaminant plume. This well and others that are in close proximity to the site boundary that are potentially in the downgradient path of the plume should be mentioned within the report.

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4. Page 10, Section 4.2.1, second paragraph, first sentence: It is stated within this section that soil gas sampling locations were determined based on a 100-foot by 100-foot sampling grid. On what technical basis was this grid size chosen? Due to the importance placed on soil gas sampling in determining the lateral extent of the contaminant plume, the soil gas discussion should be expanded (e.g. include the basis for choosing sampling locations, a figure of the sampling grid, etc...).
5. Page 4, Appendix B, last sentence: This sentence appears to conflict with the sentence noted above and misleads the reader into thinking the sampling locations were chosen haphazardly. Please clarify the technical basis for choosing soil gas sampling locations. Also, were sampling locations chosen based on the results of the previous days sampling?
6. Page 12, Section 4.4, last 3 sentences in first full paragraph: If these borings were to represent vertical control on the contaminant plume, why were only two ground water grab samples taken? How and why were these depths chosen? Explain the reasoning for bailer sampling versus collecting *in situ* samples (e.g. utilizing a hydropunch).
7. Page 12, Section 4.4, last paragraph: What precautions were taken for eliminating or reducing the risks of cross contamination - especially when significant formational heave problems were encountered?
8. Page 13, Section 4.5.2: Seismic reflection profiles should be included in the report for review purposes. Also, a figure indicating the exact locations of the profiles should be included in the report.
9. Page 14, Section 4.6, left column, second paragraph: The borehole/lithologic log should be included in the report.
10. Page 14, Section 4.6, right column, last paragraph: If the borehole reached the top of the proposed 100-foot b.g.s. low permeability layer (aquitard?), why was the monitoring/extraction well installed only to a depth of 84-feet b.g.s. Was formational heaving encountered? Please explain the rational for installation depth.
11. Page 15, Section 4.6, left column, first partial and following full paragraph: To assist the reader in understanding how the monitoring/extraction well is installed, an as-built monitoring well installation log should be included in the report (especially for a multi-interval screened well such as this one).

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12. Page 15, Section 4.6, left column, second full paragraph: What criteria was utilized to determine when the upper screened interval was fully developed?

13. Page 17, Section 5.1.1, second paragraph and Page 18, Section 5.4: To aid the reader in understanding the vertical and lateral distribution of contamination onsite and how lithologic changes are affecting the downward migration of the contaminant plume, stratigraphic cross sections showing vertical and lateral lithologic changes should be included in the report. Also, cross sections should indicate drilling locations, borehole and monitoring well total depths, and depth-specific analytical results.

14. Page 18, Section 5.4, right column, first full paragraph, last sentence: Although the PCE concentration at a depth of 95 feet is lower, it still greatly exceeds drinking water standards and does not appear to support the conclusion that contamination is confined to the upper 100 feet. Overall, it appears that these conclusions are based on very few data. Please expand discussion.

15. Page 19, Section 6.0, left column, third paragraph, last sentence: Offsite characterization data should be included within this report.

16. Plate 2: This plate is extremely hard to interpret. Sampling locations are hard to locate and contaminant concentrations are hard to identify. In some cases, contaminant concentrations can not be read at all (e.g. GZ-6 and VW&R MW-1). It would be extremely helpful to the reader if unnecessary information was removed from the plate (such as the parking lot row configuration lines and traffic direction arrows, etc...). Furthermore, infrastructural information (such as buildings etc...) could be screened during the printing process so as to appear as background information. This would highlight sampling locations and analytical data. Information provided should include borehole and monitoring well total depths. Explanation is also not provided as to why some sampling locations have more than one contaminant concentration. Please provide explanation.

17. Plate 2: This plate should be oriented consistently with the other plates within the report.

18. Plate 2: The lack of data within the highest contaminant contour interval near the northwest site boundary leads the reader to conclude that this contour was conveniently closed at the site boundary. Unless there are data to support this closure, it should remain open in the downgradient direction as do the other contours.

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Page 4

19. Plate 2: It is evident that there are limited data defining the lateral extent of the contaminant plume. These data gaps are most notable on the northeast site of the plume near the mall structures, on the southwest side near the theater, and near the site boundary. There also appears to be a lack of ground water control on the lateral and vertical extent of the contaminant plume. Additional ground water data in the lateral direction and along the northwest site boundary would strengthen the delineation of the contaminant plume.

20. Plate 2: The contaminant levels near the northwest site boundary appear to lend support to the necessity of continuing the investigation offsite....

If you have any questions regarding these comments, please call Cathy (384-3912) or myself (384-3983).

Respectfully,

 , Hazardous Materials Manager
for

Cathy Chertudi
Ground Water Coordinator

cc. Cathy Chertudi

cc/dwp/mall/mall_com



January 27, 1995

20786 00742

Mr. Rob Howarth
Idaho Department of Health and Welfare
Division of Environmental Quality
1445 N. Orchard
Boise, Idaho 83706-2239

Mall SI/RAP
Responses to IDEQ and City of Boise Comments

Dear Rob,

On behalf of Van Waters & Rogers Inc. (VW&R), Harding Lawson Associates (HLA) has prepared this letter to respond to comments received from the Idaho Department of Health and Welfare, Division of Environmental Quality (IDEQ) dated December 22, 1994, and from the City of Boise dated December 9, 1994, regarding the *Draft Final Site Investigation Report/Remedial Action Plan, Boise Towne Square Mall, Boise, Idaho* dated November 2, 1995 (SI/RAP). The comments and responses are listed below. This letter was originally submitted to IDEQ and the City in draft form. Verbal approval was received from IDEQ on January 27, 1995, to finalize this letter and include the appropriate responses in the final version of the SI/RAP. This letter will also be included in Appendix E of the SI/RAP.

IDEQ COMMENTS

Comment: Page ix, second column, first paragraph, Executive Summary; We have previously reached agreement on language that deals with possible modification of cleanup levels (CLs) based upon consideration of the forthcoming PSA risk assessment. However, this paragraph appears to assert as fact that the CLs will be revised. We request that "These, however, will be modified. . ." be changed to "These, however, may be modified. . ."

Response: The Executive Summary will be modified to reflect this comment.

Comment: Table 8. Boise Mall Order Schedule; Paragraph 15 of the Boise Mall Order (BMO) indicates that the RAP is to be revised and resubmitted within 14 days of receipt of the Department's notice that the RAP contains deficiencies. From the proposed schedule, it is not clear whether this is understood. Please confirm that all aspects of the proposed schedule correlate with paragraphs 15 through 17 of the BMO.

Response: Table 8 will be modified to reflect paragraphs 15 through 17 of the Boise Mall Order.

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CITY OF BOISE COMMENTS

The soil and groundwater investigation undertaken by VW&R at the mall has been ongoing since 1991 and has included multiple investigative phases such as soil gas, soil, and groundwater sampling, well installation and geophysical surveys. Investigative activities completed and their associated delivery schedule were defined in a consent order dated October 9, 1992, between VW&R and the IDEQ. Each investigative step has been described in reports submitted to the IDEQ as the investigation progressed. Prior to proceeding to the next activity, IDEQ approval was required. As stated in the SI/RAP, it was not VW&R's intention to reproduce all the details of each investigative activity completed as part of the soil and groundwater characterization at the mall. Rather, a summary of those activities and associated conclusions were assembled as the SI/RAP and appropriate references were provided should additional details or background material be sought by the reader.

Comment 1: Pages 2-5, Section 2.2: To clarify the multiple sampling events conducted at the site, it would be helpful to include figures (i.e., plates 3, 4, and 5) and tables immediately following the discussion of each investigation. The figures and tables should show sampling locations, total depths (if appropriate), and analytical results.

Response: The figures and tables corresponding to individual sampling events were included in the report at the end of the text section in the sections labelled "Tables" and "Plates".

Comment 2: Page 8, Section 3.3: A stratigraphic column of the geologic units studies in the investigations should be included in this section.

Response: Section 3.3 provides an overview of the regional geology and hydrogeology. A written discussion of the lithologies encountered at the site was included in Section 7.1. However, a cross section presenting lithologic and chemical data will be prepared and included in the report (See the response to Comment 13).

Comment 3: Page 9, Section 3.4: Although it is mentioned that potable water at the site is supplied by Boise Water Corporation, it is not mentioned that there is an offsite Boise Water Corporation water supply well in the downgradient path of the contaminant plume. This well and others that are in close proximity to the site boundary that are potentially in the downgradient path of the plume should be mentioned within the report.

Response: The Boise Water Corporation water supply well (Bali Hai Well) is approximately 2 miles downgradient of the western property boundary of the Mall. As the City is aware from the numerous West Boise Advisory Group meetings, the Bali Hai well, as well as other wells downgradient of the Mall, are being addressed in ongoing investigations being conducted under a separate consent order between VW&R and the IDEQ (the PSA Order).

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Comment 4: Page 10, Section 4.2.1, second paragraph, first sentence: It is stated within this section that soil gas sampling locations were determined based on a 100-foot by 100-foot sampling grid. On what technical basis was this grid size chosen? Due to the importance placed on soil gas sampling in determining the lateral extent of the contaminant plume, the soil gas discussion should be expanded (e.g., include the basis for choosing sampling locations, a figure of the sampling grid, etc. . .).

Response: The soil gas sampling locations were proposed in the Mall Work Plan which was approved by the Department. A plate showing the grid and proposed sampling locations was provided in the Mall Work Plan. A grid system ensures representative sampling locations. The spacings between grid lines are chosen to provide adequate sampling locations in the area of evaluation. Sampling points may vary slightly from those proposed due to the presence of utilities or access to the specific location. In addition, sampling points may be modified from those proposed based on real-time data collection activities.

Comment 5: Page 4, Appendix B, last sentence: This sentence appears to conflict with the sentence noted above and misleads the reader into thinking the sampling locations were chosen haphazardly. Please clarify the technical basis for choosing soil gas sampling locations. Also, were sampling locations chosen based on the results of the previous days sampling?

Response: The sampling locations were not chosen haphazardly. The previous response explains how sampling locations were chosen. The sentence referenced in this comment is located in the report provided by the soil gas subcontractor, Hydro Geo Chem (Appendix B). Hydro Geo Chem personnel did not choose the sampling locations, but were directed by HLA to sample at specific locations as defined by the IDEQ-approved Mall Work Plan. Sampling points were primarily chosen using the grid system referenced in the Mall Work Plan. However, some locations were chosen based on analytical results obtained in the field to maximize the information gathered during the survey.

Comment 6: Page 12, Section 4.4, last 3 sentences in first full paragraph: If these borings were to represent vertical control on the contamination plume, why were only two groundwater grab samples taken? How and why were these depths chosen? Explain the reasoning for bailer sampling versus collecting *in situ* samples (e.g. utilizing a hydropunch).

Response: The scope of work proposed in the Pilot Boring Sampling and Analysis Plan included collecting hydropunch samples at approximately 20 foot intervals; however, field conditions encountered prohibited the use of the hydropunch at

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some of the proposed sampling depths (i.e., gravels were encountered in the boreholes and the hydropunch could not be driven into the formation for groundwater sample collection). Grab groundwater samples were collected using a stainless steel bailer at intervals where formational heaving problems were not encountered. Section 4.4 will be expanded to include this response.

Comment 7: Page 12, Section 4.4, last paragraph: What precautions were taken for eliminating or reducing the risks of cross contamination - especially when significant formational heave problems were encountered?

Response: The boreholes were drilled using air casing hammer drilling techniques. This will be added to page 12. Cross contamination is unlikely because the drilling technique utilized steel casing that is hammered into the ground as the boring advanced. Formational heave is upward (deeper sands entering the inside of the casing), and is hydraulically or mechanically removed from the inside of the casing.

Comment 8: Page 13, Section 4.5.2: Seismic reflection profiles should be included in the report for review purposes. Also, a figure indicating the exact locations of the profiles should be included in the report.

Response: Seismic reflection profiles are recorded on long, narrow strips of paper and would be technically difficult to include in the report. The profiles are available for review upon request. The locations of the seismic reflection profiles will be added to Plate 2.

Comment 9: Page 14; Section 4.6, left column, second paragraph: The borehole/lithologic log should be included in the report.

Response: The lithologic log and well completion diagram was provided to the Department in the January through March 1994 Quarterly Progress Report. This reference will be added to Section 4.6.

Comment 10: Page 14, Section 4.6, right column, last paragraph: If the borehole reached the top of the proposed 100-foot b.g.s. low permeability layer (aquitard?), why was the monitoring/extraction well installed only to a depth of 84-feet b.g.s. Was formational heaving encountered? Please explain the rationale for installation depth.

Response: Due to the loose nature of the formation encountered in the bottom of the borehole, a section of steel blank casing was installed from a depth of 84 to 94 feet to act as a stable base upon which to construct the remainder of the well. The steel casing present at the bottom of the borehole was grouted in place which also served to prevent additional downward migration of higher concentrations of PCE above a depth of 80 feet. Well construction details were approved by IDEQ prior to construction.

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Comment 11: Page 15, Section 4.6, left column, first partial and following full paragraph: To assist the reader in understanding how the monitoring/extraction well is installed, an as-built monitoring well installation log should be included in the report (especially for a multi-interval screened well such as this one).

Response: The well completion diagram has been previously provided to the Department in the January - March 1994 Quarterly Report.

Comment 12: Page 15, Section 4.6, left column, second full paragraph: What criteria was utilized to determine when the upper screened interval was fully developed?

Response: In accordance with the Quality Assurance Project Plan, the well was developed using a submersible pump until the discharged water was visibly clear and free of sediment.

Comment 13: Page 17, Section 5.1.1, second paragraph and Page 18, Section 5.4: To aid the reader in understanding the vertical and lateral distribution of contamination onsite and how lithologic changes are affecting the downward migration of the contaminant plume, stratigraphic cross sections showing vertical and lateral lithologic changes should be included in the report. Also, cross sections should indicate drilling locations, borehole and monitoring well total depths, and depth-specific analytical results.

Response: A cross section will be prepared and included in the report.

Comment 14: Page 18, Section 5.4, right column, first full paragraph, last sentence: Although the PCE concentrations at a depth of 95 feet is lower, it still greatly exceeds drinking water standards and does not appear to support the conclusion that contamination is confined to the upper 100 feet. Overall, it appears that these conclusions are based on very few data. Please expand discussion.

Response: As indicated on page 18, a PCE concentration of 24 ug/l was detected at a depth of 95 feet. A low permeability layer (clay layer) was encountered at an approximate depth of 100 feet. Because low permeability layers can prevent deeper migration of contaminants and because the total thickness of the clay layer is not known, it is technically unsound to compromise the integrity of a low permeability layer to collect samples within or beneath the layer.

Comment 15: Page 19, Section 6.0, left column, third paragraph, last sentence: Offsite characterization data should be included within this report.

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Mr. Rob Howarth
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Response: Offsite characterization is being conducted under a separate Consent Order with the IDEQ and is ongoing. Results of the offsite investigation will be presented in a Site Investigation Report for the Preliminary Study Area (PSA; the area downgradient of the Mall) and is expected to be submitted to the IDEQ in draft form in February 1995.

Comment 16: Plate 2: This plate is extremely hard to interpret. Sampling locations are hard to locate and contaminant concentrations are hard to identify. In some cases, contaminant concentrations can not be read at all (e.g. GZ-6 and VW& MW-1). It would be extremely helpful to the reader if unnecessary information was removed from the plate (such as the parking lot row configuration lines and traffic direction arrows, etc. . .). Furthermore, infrastructural information (such as building etc. . .) could be screened during the printing process so as to appear as background information. This would highlight sampling locations and analytical data. Information provided should include borehole and monitoring well total depths. Explanation is also not provided as to why some sampling locations have more than one contaminant concentration. Please provide explanation.

Response: The base map provided by the Mall management will be modified to more readily distinguish soil gas and groundwater quality data from the other physical features presented on the map. Elimination of prominent landmarks, such as parking lot row configurations, and traffic direction arrows, etc., was not done as these provide necessary reference points and perspective to the investigatory team. The explanation will be modified to include duplicate samples (wells with more than one concentration reported).

Comment 17: Plate 2: This plate should be oriented consistently with the other plates within the report.

Response: The base map was provided by the Mall management with the existing orientation.

Comment 18: Plate 2: The lack of data within the highest contaminant contour interval near the northwest site boundary leads the reader to conclude that this contour was conveniently closed at the site boundary. Unless there are data to support this closure, it should remain open in the downgradient direction as do the other contours.

Response: Based on data downgradient of the Mall obtained following completion of the SI/RAP, the 1000 ug/l contour line will be revised to remain open at the northwest portion of the site.

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Mr. Rob Howarth
Idaho Department of Health and Welfare
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Comment 19: Plate 2: It is evident that there are limited data defining the lateral extent of the contaminant plume. These data gaps are most notable on the northeast site of the plume near the mall structures, on the southwest side near the theater, and near the site boundary. There also appears to be a lack of ground water control on the lateral and vertical extent of the contaminant plume. Additional ground water data in the lateral direction and along the northwest site boundary would strengthen the delineation of the contaminant plume.

Response: Adequate data, including soil gas and groundwater data, exist to define the lateral extent of the plume and support the recommended remedial action at the site. Soil gas data is an excellent qualitative tool typically used in sandy environments to delineate the lateral extent of VOCs in groundwater, particularly where the site encompasses a large area such as a mall parking lot. These data combined with groundwater analytical data from existing monitoring wells were used to define the lateral extent of PCE in groundwater.

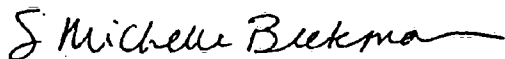
Comment 20: Plate 2: The contaminant levels near the northwest site boundary appear to lend support to the necessity of continuing the investigation offsite. . . .

Response: The City of Boise has been involved with the West Boise Advisory Group, a group monitoring and commenting on the VW&R project, since consent orders were signed in 1992. This group meets quarterly for an update on the project and to discuss issues and make suggestions in the direction of the project. The next group meeting is scheduled for January 24, 1995, at the IDEQ office at 1445 N. Orchard at 1:30 pm. As you are aware, numerous investigations are ongoing in the offsite area.

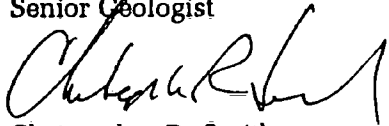
If you have any questions, please call either of the undersigned at (415) 883-0112 or Mike Gaudette of VW&R at (1-800) 284-6264 ext. 8455.

Yours very truly,

HARDING LAWSON ASSOCIATES



S. Michelle Beekman
Senior Geologist



Christopher R. Smith
Principal Hydrogeologist

SMB/CRS/JC38474-V

DISTRIBUTION

Final Site Investigation Report/
Remedial Action Plan
Boise Towne Square Mall
Boise, Idaho

January 27, 1995

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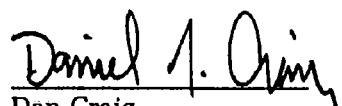
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Boise, Idaho

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Quality Control Reviewer


Dan Craig
Associate Hydrogeologist

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Engineering and Environmental Services

